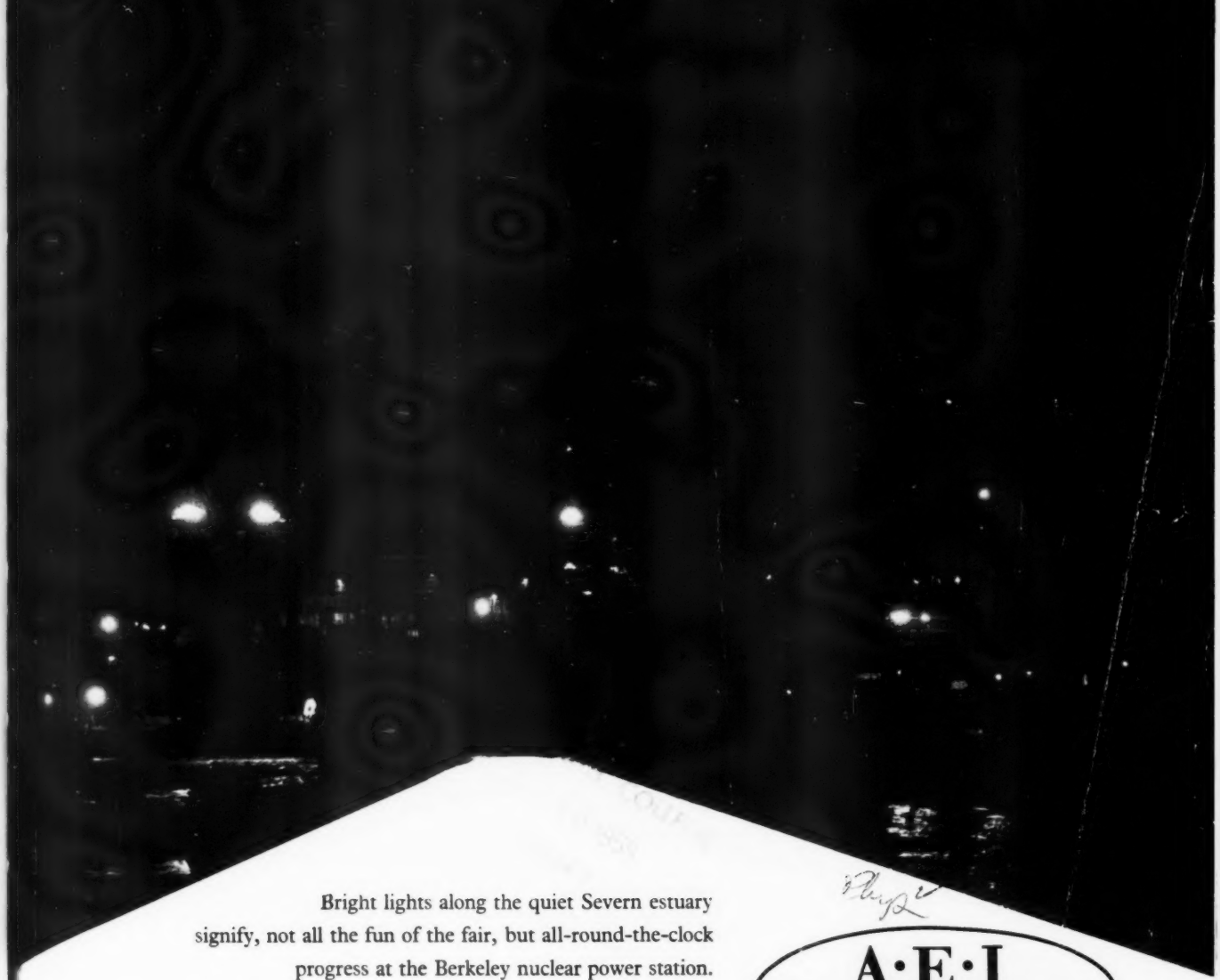
Nuclear Power

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

Gloucestershire night life...



Bright lights along the quiet Severn estuary signify, not all the fun of the fair, but all-round-the-clock progress at the Berkeley nuclear power station. The first of Britain's commercial nuclear power stations is growing fast. Work is up to schedule. The AEI-John Thompson Company continues to work flat out for the nation's future.

A·E·I
JOHN THOMPSON

A ROWSE MUIR PUBLICATION

MARCH 1958 3/6

ZETA

was

built by

METROPOLITAN-VICKERS

The Zero Energy Thermo-Nuclear Assembly with which the Atomic Energy Research Establishment, Harwell achieved temperatures up to 5,000,000°C on the 30th August, 1957, was built by Metropolitan-Vickers. They also collaborated in the design of this equipment which was the first to produce temperatures of this order.

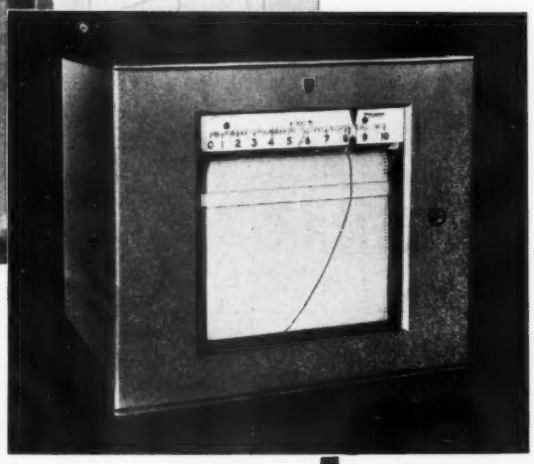
METROPOLITAN-VICKERS
ELECTRICAL CO LTD TRAFFORD PARK MANCHESTER 17

An A.E.I. Company

LEADING ELECTRICAL PROGRESS

TGA AZ801

Tick **No 1** on reply card for further details



To position the chart paper with hair-line accuracy, it is only necessary to disconnect the chart-drive by means of a simple lever, and to adjust the position of the paper with the knob shown above. Returning the release lever re-engages the drive, which is through a four-speed gearbox.

Start right with

PHILIPS

potentiometric recorders

Philips potentiometric recorders are *trusted* instruments. Whether applied to experimental and behaviour studies, for building into equipment or to industrial process control they have earned the confidence of the most experienced users.

If you are concerned with the measurement, recording or control of any variable such as temperature, conductivity, strain, vibration, pressure, radiation or any phenomenon to which a transducer or other primary measuring element is responsive, get to know about potentiometric recorders by Philips.

Operating on the servo-operated null-balance principle, Philips potentiometric recorders are available as single-channel instruments, in double-channel form and as multiple-channel recorders up to twelve positions. From a comprehensive range there is an instrument to meet every need. Write now for fully descriptive literature.

PHILIPS ELECTRICAL LTD

RESEARCH & CONTROL INSTRUMENTS DIVISION
Century House · Shaftesbury Avenue · London · WC2
Telephone: GERrard 7777

(PRC0264)

production engineers

fully equipped for the manufacture of

graphite components.

fabricators of

special equipment *for the*

ATOMIC ENERGY AUTHORITY

If YOU have a special problem, apply to:

Registered Office:
29 ST. JAMES'S ST.,
LONDON, S.W.1.
Tel.: Whitehall 6478

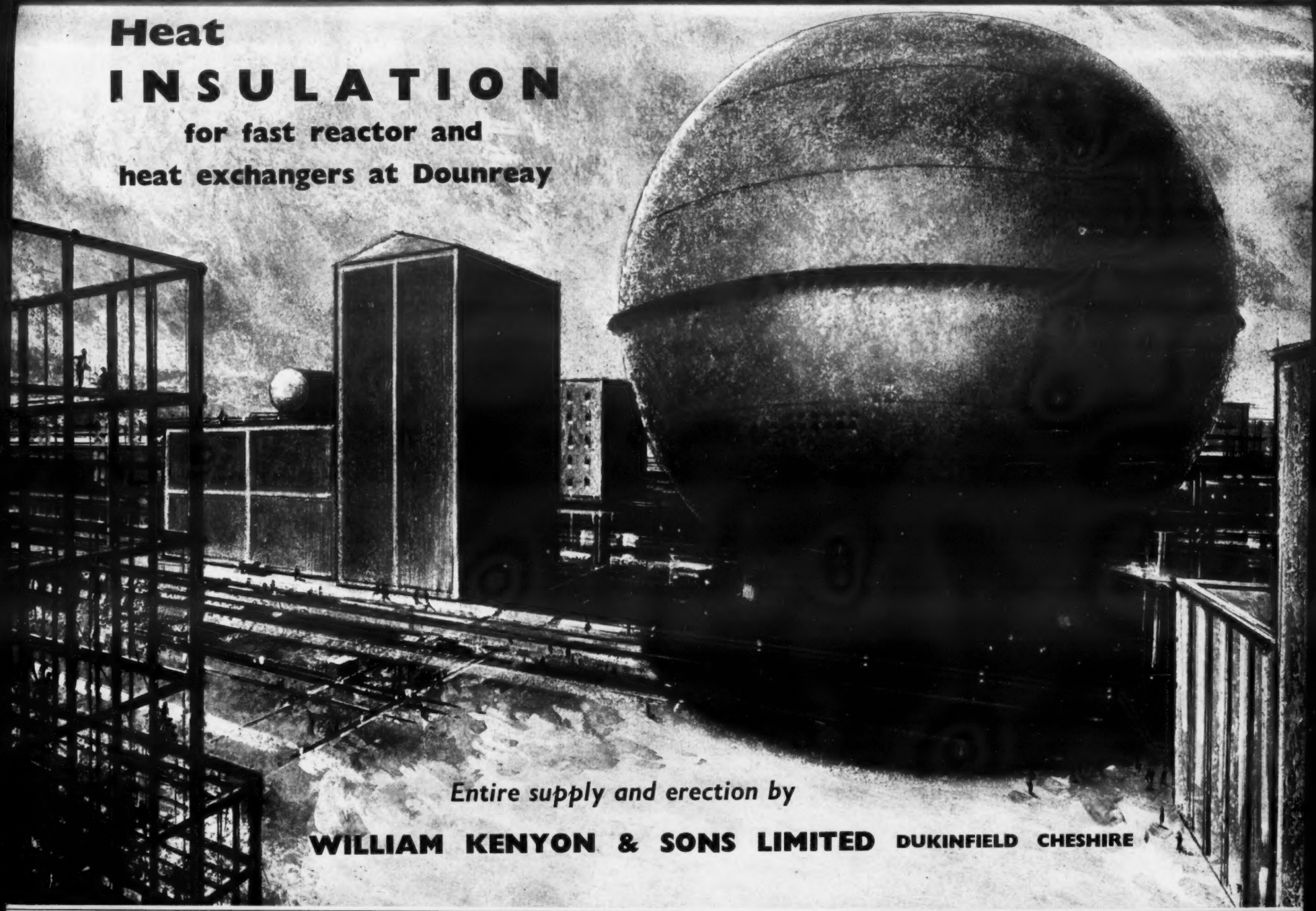
GRAVINER MFG. CO., LTD.,
Fareham Road, Gosport, Hants.
Tel.: Gosport 89175

Aircraft Division:
POYLE MILL WORKS,
COLNBROOK, BUCKS.
Tel.: Colnbrook 2345

also specialists in Industrial Explosion Protection, Airborne Fire Protection Equipment, Thermostats and Overheat Switches.

Heat INSULATION

for fast reactor and heat exchangers at Dounreay



Entire supply and erection by

WILLIAM KENYON & SONS LIMITED DUKINFIELD CHESHIRE

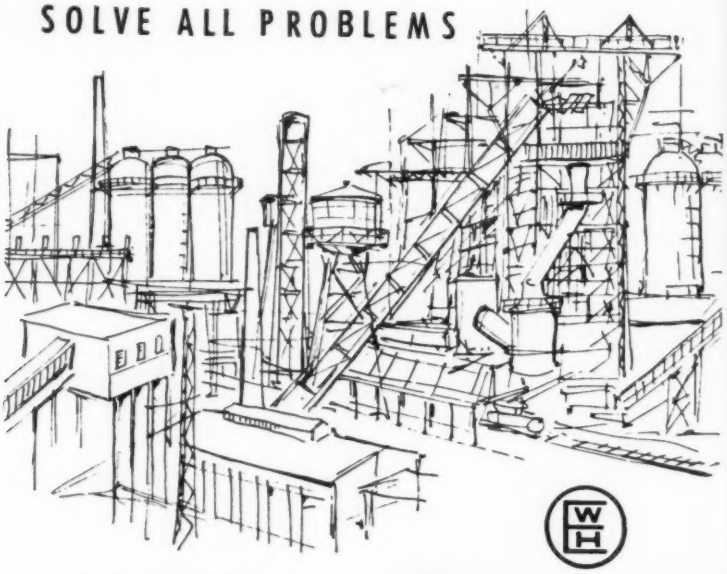
Tick **No 4** on reply card for further details

THE WORLD-WIDE-FAMOUS

ERHARD
VALVES

known for their Design, Precision and Quality for more than 80 years.

SOLVE ALL PROBLEMS



JOHANNES ERHARD H. WALDENMAIER ERBEN
Süddeutsche Armaturenfabrik, Heidenheim / Brenz · Germany
Telephone 3881 Cable · Erhardarmaturen

For all information write to:

The Sole Agents for the United Kingdom

A.K. STARCK'S CO. LTD. 22, Chancery Lane London W.C. 2
Telephone Holborn 2966 Cable: Akstar London

Tick No 5 on reply card for further details

Willans now offer Industry a VACUUM MELTING SERVICE

A high vacuum melting and pouring furnace has recently been installed by G. L. Willan Ltd. This is to meet the increasing demand for special high duty alloys with hitherto unobtainable properties, especially at high temperatures.

Recent technical developments demand exceptional purity and very low gas content in alloy steels and melting under vacuum is proving to be the answer to the problems of producing such steels.

Willans have had considerable experience in making special alloy steels and they invite enquiries from metallurgical engineers who require such steels with specific properties. Vacuum melting may well prove to be the solution to their problems.

G. L. WILLAN LTD.

(Approved A.I.D., D.I. Arm., A.R.B.)

Steel Manufacturers

Sussex Street, Sheffield 4. Telephone 24211

0A4405

Tick **No 6** on reply card for further details

ZIRCONIUM

reactor grade zirconium
commercial grade zirconium
zirconium alloys

are available from

Jessop

VACUUM MELTING FURNACES

Hylite **TITANIUM ALLOYS**

10 Commercially pure titanium, supplied to D.T.D. specifications 5013 and 5033. Resistance to corrosion with maximum formability and weldability where strength is not critical.

15 Commercially pure titanium supplied to D.T.D. specifications 5003 and 5023.

20 5% Aluminium, 2½% Tin Alloy. An Alpha alloy of moderate strength. Being readily weldable and easily formed it is suitable for sheet metal work where higher strength than Hylite 10 is required.

30 2% Manganese, 2% Aluminium Alloy. A relatively low alloy bridging the gap between commercially pure and the high strength alloys.

40 4% Manganese, 4% Aluminium Alloy. A higher strength alloy suitable for compressor discs and blades.

45 6% Aluminium, 4% Vanadium. A high strength alloy which responds to heat treatmen.. Available in sheet form as well as rolled bar and forgings.

50 A complex aluminium alloy having greater strength combined with excellent creep resisting properties.

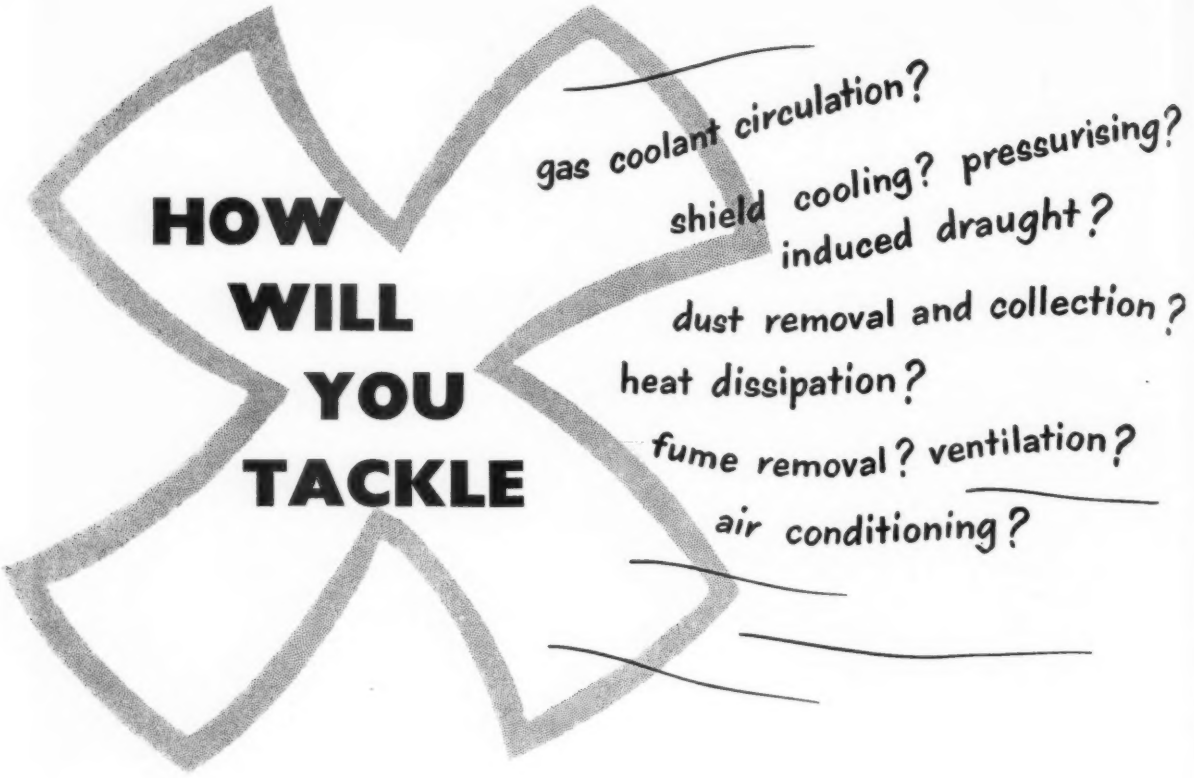
WILLIAM JESSOP & SONS LTD · BRIGHTSIDE WORKS · SHEFFIELD

A MEMBER OF THE BSA GROUP

TELEPHONE 41352 (7 LINES) · TELEGRAMS IESSOP SHEFFIELD 9

BRITISH OXYGEN serves the interests of nuclear progress and research— particularly in the field of ARGON WELDING

British Oxygen Gases Limited, Industrial Division, Spencer House, 27 St. James's Place, London, S.W.1.



Keith Blackman can supply every type of special air or gas handling equipment you are likely to need. Made of appropriate materials and ruggedly constructed, it will deal with high pressures, high temperatures, large volumes and any other arduous conditions. 74 years' experience has made us specialists in the unusual, and we believe in designing 'the fan for the job'. Yet your more conventional requirements can be met by our very comprehensive stock of standard equipment.

Every fan, special or standard, undergoes exacting running tests for maximum reliability; we know how the breakdown of one unit can start a chain of other stoppages, resulting in costly delay.

When only the best is good enough, take it from us

Tornado

FAN ENGINEERING EQUIPMENT

KEITH BLACKMAN LIMITED · LONDON AND ARBROATH
HEAD OFFICE: MILL MEAD ROAD, LONDON, N.17

Suppliers of fans and blowers to U.K.A.E.A. plants at Aldermaston, Capenhurst, Dounreay, Foulness, Harwell, Risley, Springfields and Windscale.

TA 10484/785

Tick **No 9** on reply card for further details

20th CENTURY

TUBES FOR REACTOR INSTRUMENTATION

SLOW & FAST NEUTRON DETECTORS

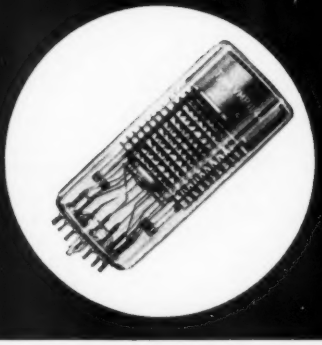
For detecting and measuring thermal neutron flux BF_3 proportional counters are available in which BF_3 gas enriched in B-10 is used at a variety of pressures to cover a wide sensitivity range.
Fast neutron health hazard can be directly assessed by the FN series of proportional counters which are designed to simulate tissue response to fast neutrons.

FISSION CHAMBERS

The fission chamber type B165 operating as a pulse ion chamber, is currently employed as a detector of neutrons in the pulse counting equipment of reactor instrumentation.
Internal coatings of enriched or depleted fissile material are available in the B165 and in smaller chambers which have been designed for use as probes in neutron flux investigations.

PHOTO MULTIPLIERS

A range of photo-multiplier tubes is available for scintillation counting, energy resolution and applications where linear high current output is necessary.
These tubes employ from 6 to 18 stages of multiplication and the smallest has an overall diameter of $\frac{3}{4}$".

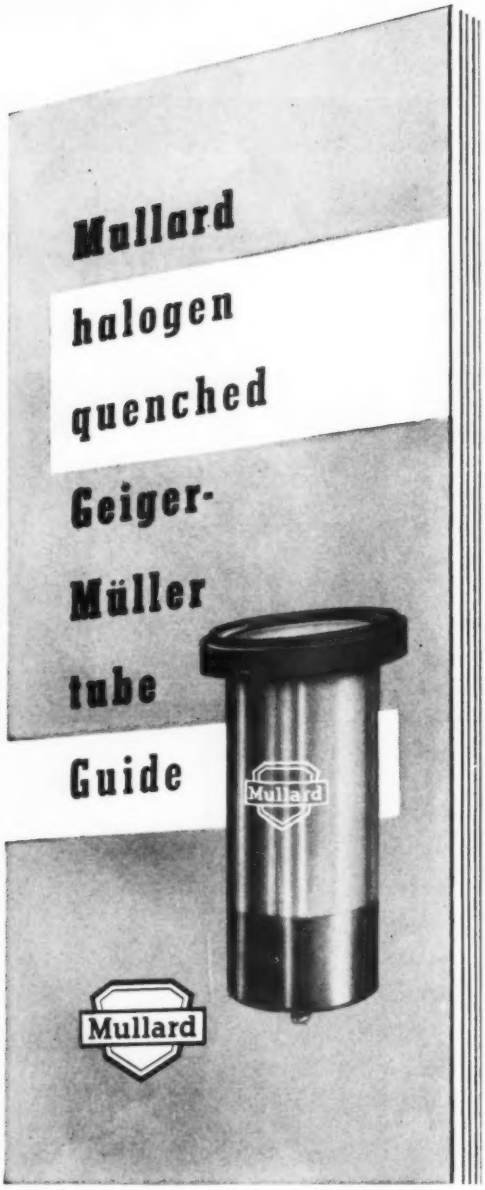


20th CENTURY ELECTRONICS LIMITED

CENTRONICS WORKS • KING HENRY'S DRIVE

NEW ADDINGTON • CROYDON • SURREY • *Lodge Hill 2121*

Tick **No 10** on reply card for further details



Do you use Geiger Müller Tubes?

To meet an ever growing demand in the fields of medicine research and industry, Mullard have developed a comprehensive range of Geiger Müller Tubes that includes types for almost every application.

Then get your copy of this valuable tube guide

This guide has been prepared to assist users of Geiger Müller Tubes in selecting the right tube from the Mullard range for optimum performance in any given application. It is a valuable source of reference. Make sure of your copy by writing to the address below now.

It will help you choose the best tube for the job

To Mullard Limited, X-ray Division, New Road, Mitcham Junction, Surrey.
Please supply us with.....copies of your Geiger Müller Tube Guide.

NAME .....

ADDRESS .....

.....

..... N.P.

Mullard

X-RAY DIVISION

MULLARD LTD., X-RAY DIVISION,
NEW ROAD, MITCHAM JUNCTION, SURREY
Telephone: Mitcham 3471

MXR 500

When the job is

"difficult..."

These multi slipring units with 46 rings were designed, developed and are being produced by us for Messrs. John Curran Ltd. of Cardiff. A similar type of unit but with 61 rings has been designed and manufactured for use by the United Kingdom Atomic Energy Authority on an acceleration test machine.

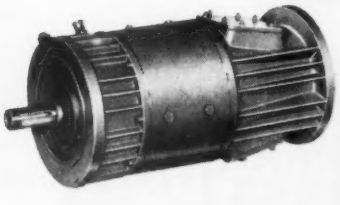
Our business is to design and develop the "difficult" things which may be holding up your production and to manufacture under sub-contract components or complete equipments that it may be inconvenient for you to make yourselves.

If you have a "difficulty" or production bottle-neck we can most likely help you.

The same know-how that enabled us to overcome the difficulties inherent in the design of the above has gone into the making of many other types of special electro/mechanical equipment which we have produced for well-known engineering firms. For instance

High cycle blowers.	*Aircraft motors.*
Flame-proof hot air blowers.	*Automatic controls.*
Ship electric whistles.	*Heavy duty solenoids.*

produced by the manufacturers of the



Example of series commutator motor developing 8 H.P. at 3,750 r.p.m., designed to comply with an Admiralty Specification, and to withstand the arduous conditions encountered in all climates when fitted at a ship's mast head to drive an electric whistle.

Secomak REG^{D}

range of industrial blowing and suction equipment and sound signalling appliances

SERVICE ELECTRIC CO., LTD. HONEYPOT LANE, STANMORE, MIDDLESEX

Manufacturing Electrical and Mechanical Engineers. Contractors to Admiralty and Ministry of Supply. A.I.D. approved

EDGware 5566/9

Micro Switchcraft by

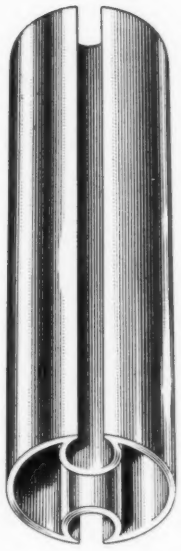
BURGESS

THE BRITISH MICRO SWITCH DESIGN
AND MANUFACTURING SPECIALISTS

BURGESS PRODUCTS CO. LTD., MICRO SWITCH DIVISION, DUKES WAY, TEAM VALLEY, GATESHEAD 11. Tel: Low Fell 75322. Telex: 53-229

Some recent developments in manufacturing techniques and special applications of tubes in a variety of metals...

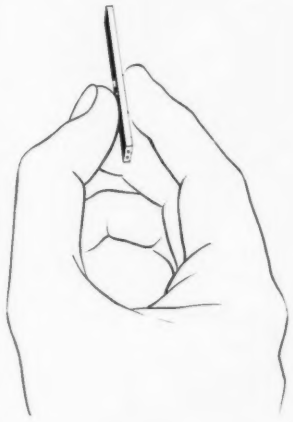
No. 1 OF A SERIES BY ACCLES & POLLOCK



A special section used in sliding door mechanism, the dimensions are: 1″ diameter to take 5/16″ rollers.

Helically convoluted seamless stainless tubing, available in a range of sizes. Can be supplied convoluted in continuous lengths, or with plain ends, or with plain portions at any intermediate point along the tube.

A rectangular tube in pure nickel: .111″ x .045″ A/F with twin bores of .020″ diameter; used in the electrical industry.



Designers have a habit of asking for the impossible, but in a surprising number of cases Accles & Pollock produce an answer that enables the production people to translate the concept on the drawing board into a physical, functional form. Accles & Pollock welcome all such opportunities to co-operate in developing new applications in the form of tubes and tubular sections.

Accles & Pollock

Accles & Pollock Limited · Oldbury · Birmingham · A Tube Investments Company

Makers and manipulators of COLD DRAWN SEAMLESS and WELDED PRECISION TUBES in carbon and alloy steel, including stainless steel, and other metals

tzw/218

Pattern of protection

The persistent upward trend of maintenance costs is a bugbear that can throw any budget out of gear and the cost of genuine red lead is one of the contributory factors. Now leading authorities specify "Superlative" Metal Primer to offset much of this cost. "Superlative" ensures complete protection for all ferrous metals. And as well as saving in initial material costs it has the advantages of easier, quicker application than red lead and greater coverage. Resultant reduced labour charges emphasize further the lower maintenance costs effected by "Superlative" Metal Primer.

'Superlative' Metal Primer prevents corrosion economically. *Our Techniservice will gladly answer all enquiries*

BRITISH PAINTS LIMITED

Portland Road, Newcastle upon Tyne, 2.
Crewe House, Curzon St., London, W.1.

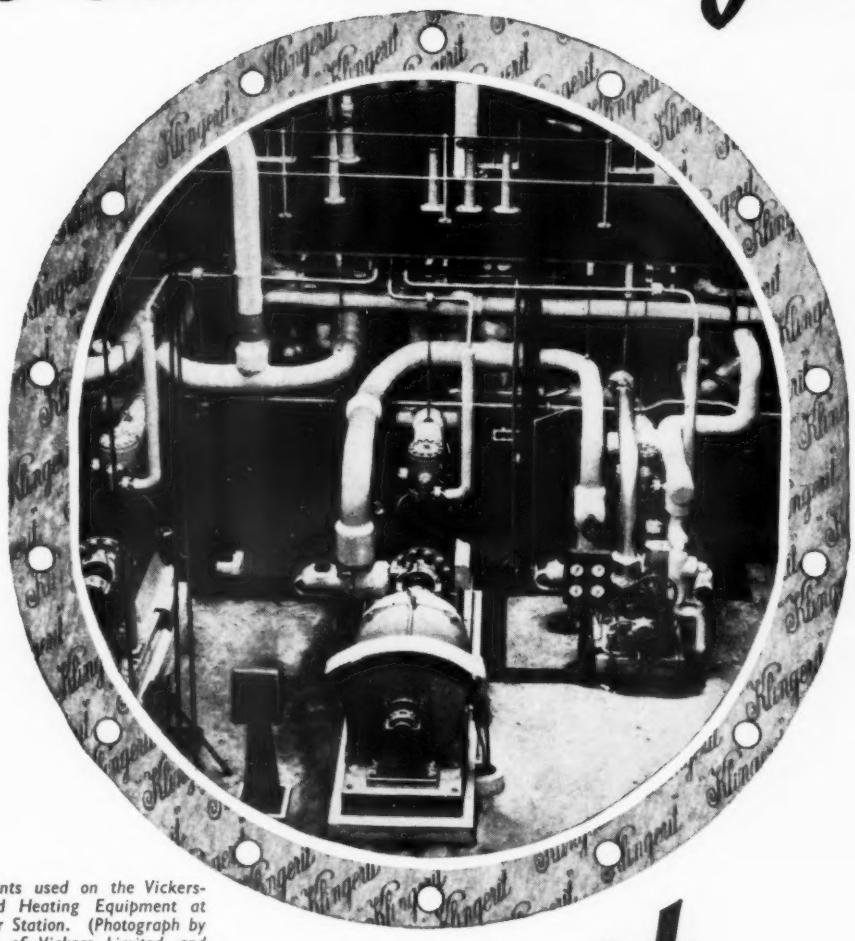
Sydney, Adelaide, Toronto, Durban, Cape Town, Calcutta, Trinidad, New York, Arklow

Our world-wide service is at your disposal for the asking

BPL/IM11

Tick **No 15** on reply card for further details

Cut out for the job!



"Klingerit" joints used on the Vickers-Armstrongs Feed Heating Equipment at Fleetwood Power Station. (Photograph by kind permission of Vickers Limited and the Central Electricity Generating Board.)

Klingerit JOINTINGS

RICHARD KLINGER LIMITED, KLINGERIT WORKS, SIDCUP, KENT. ***Telephone: Foots Cray 7777***

G24/58/J

$$\Pi = \sum_{i=1}^{n+1} a_i \beta_i$$

CONFERENCE NOTES

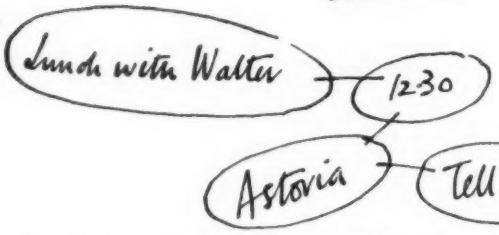
$$\sum_{i=1}^{n+1} \beta_i'^2$$

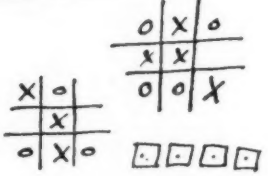
10 am : Possible energy source 100,000 curies (radio-caesium)

Heavy Water Reactor / 10-12 tons 15 MWS 66. turnup — means 67,500 tons (C)

U·K·A·E·A

Walter 26428 Rockefield

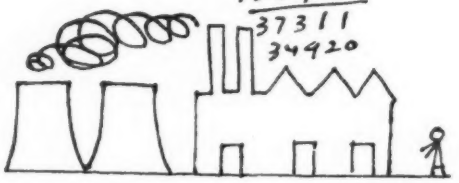


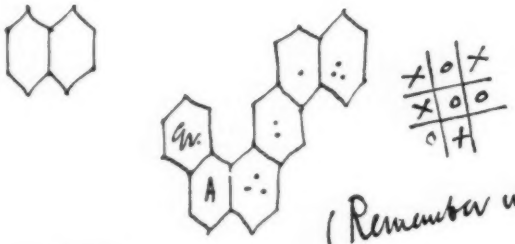


25% increased prod. Isotopes use in POLYMERISATION ?

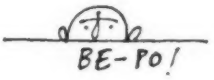
Gas/liquid cooled reactor (Gas mod.)

138
4365 | 6043618
4365
16826
13095
37311
34920



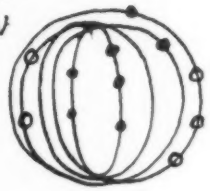


(Remember umbrella—Astoria)



Walter again—dinner ?

Anticipated output 2000 MW in '65

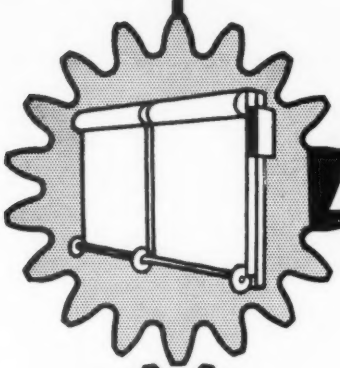


U 235
U 238

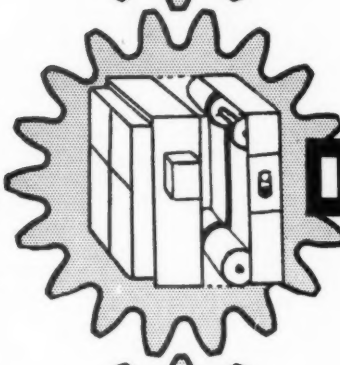
see NEWALLS re. insulation of new installation

NEWALLS INSULATION CO. LTD., *Head Office:* WASHINGTON, CO. DURHAM, ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and vendors in most markets abroad.

Tick **No 17** on reply card for further details

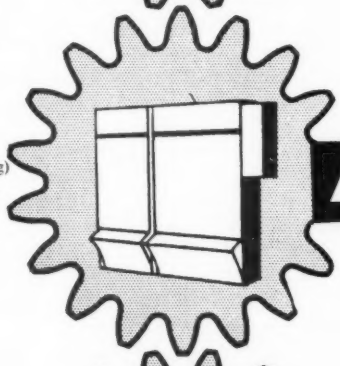


AUTOMATION



IN

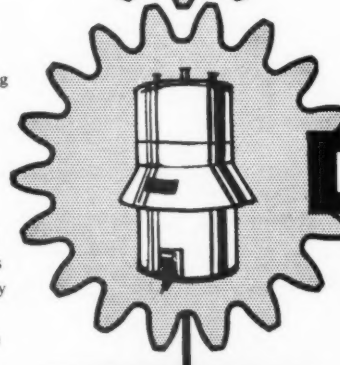
ROLL-O-MATIC
(Patents Pending)
A self-maintaining filter with a renewable curtain of bonded glass fibre. More Roll-O-Matic filters are in service than any other make of filter of this type.



AIR

ROLLOTRON
(World Patents Pending)
A unique combination of high efficiency electrostatic precipitation and automatic renewing media.

MULTI-DUTY
An original design of positive self-cleaning viscous impingement filter.



FILTRATION

CYCOIL
A compact filter combining centrifugal separation and viscous impingement; specially developed for air compressors and large diesel engines.

Filter maintenance is a thing of the past with our range of self-maintaining filters. Once installed, they work automatically and need little more than routine inspection at infrequent intervals. May we send you full details?

AIR CONTROL
INSTALLATIONS LIMITED

RUISLIP · MIDDLESEX · RUISLIP 4066

LONDON · BIRMINGHAM · MANCHESTER · NEWCASTLE · GLASGOW

Air Control Installations Ltd are the sole manufacturing licensees in Great Britain for products of the American Air Filter Co., Inc.

NS FILTERS · DUST COLLECTORS · AIR CONDITIONERS · FANS · FILTERS · DUST COLLECTORS · AIR CONDITIONERS · FANS · FILTERS · DUS

THE PHYSICAL SOCIETY

42nd EXHIBITION OF SCIENTIFIC INSTRUMENTS AND APPARATUS

1958

at the Royal Horticultural Society's Old and New Halls, Westminster, London, S.W.1

from Monday, 24th March to Thursday, 27th March

Opening Ceremony: Monday, 24th March, 1958, at 11 a.m.

Professor N. F. MOTT, F.R.S.

Discourses at 5.45 p.m. on

Monday, 24th March	"Goethe's Colour Experiments," by Mr. M. H. Wilson.
Tuesday, 25th March	"Some Uses of Physics in Archaeology," by Dr. E. T. Hall.
Wednesday, 26th March	"Some Recent Investigations with Aircraft on the Physics of Clouds and Rain," by Mr. R. J. Murgatroyd.

This Exhibition is a unique one in that emphasis is placed on new developments in scientific instruments and apparatus and on the possibility of new applications for these developments. Both exhibitors and visitors are not only willing but are anxious to discuss and gain insight into each other's problems.

In connection with the Exhibition a **HANDBOOK of SCIENTIFIC INSTRUMENTS and APPARATUS** of some 300 pages is published in which are included, in more detail than is usual in an exhibition catalogue, descriptions of the various items to be exhibited. *Now ready*, Price 6*s*. (2*s*. 6*d*. to Members); postage 1*s*. 8*d*.

Tickets of admission free on application with stamped addressed envelope to:—

THE PHYSICAL SOCIETY · 1 Lowther Gardens, Prince Consort Road, London, S.W.7

REPORTS ON PROGRESS IN PHYSICS

VOLUME XX (1957)

S. RAIMES. Theory of plasma oscillations in metals.

J. WILKS. Theory of liquid ^{4}He.

A. E. TAYLOR. High energy protons.

D. TER HAAR. Theories of collective behaviour.

R. H. DALITZ. K-mesons and hyperons. Their strong and weak interactions.

D. M. S. BAGGULEY and J. OWEN. Microwave properties of solids.

J. S. COURTNEY-PRATT. A review of the methods of high-speed photography.

J. W. MITCHELL. Photographic sensitivity.

E. R. DOBBS and G. O. JONES. Theory and properties of solid argon.

Cumulative index for volumes XVI-XX.

Price £3 3*s*. (27*s*. 6*d*. to Members); postage 2*s*.

Separate articles are available at 7*s*. 6*d*. to 10*s*. 6*d*., postage 6*d*.

VOLUME XXI (1958)

This volume will appear in the early summer and will contain the following articles:

D. H. PARKINSON. The specific heats of metals at low temperatures.

S. C. CURRAN and J. M. VALENTINE. Average energy expenditure per ion pair in gases and gas mixtures.

D. M. BRINK. The theory of collective excitations in nuclei.

J. M. COWLEY and A. L. G. REES. Fourier methods in structure analysis by electron diffraction.

W. LOCHTE-HOLTEGREVEN. Measurement and production of high temperatures.

P. FATT. Physics of nerve processes.

R. HUBY. Electromagnetic excitation of nuclei by nuclear projectiles and electrons.

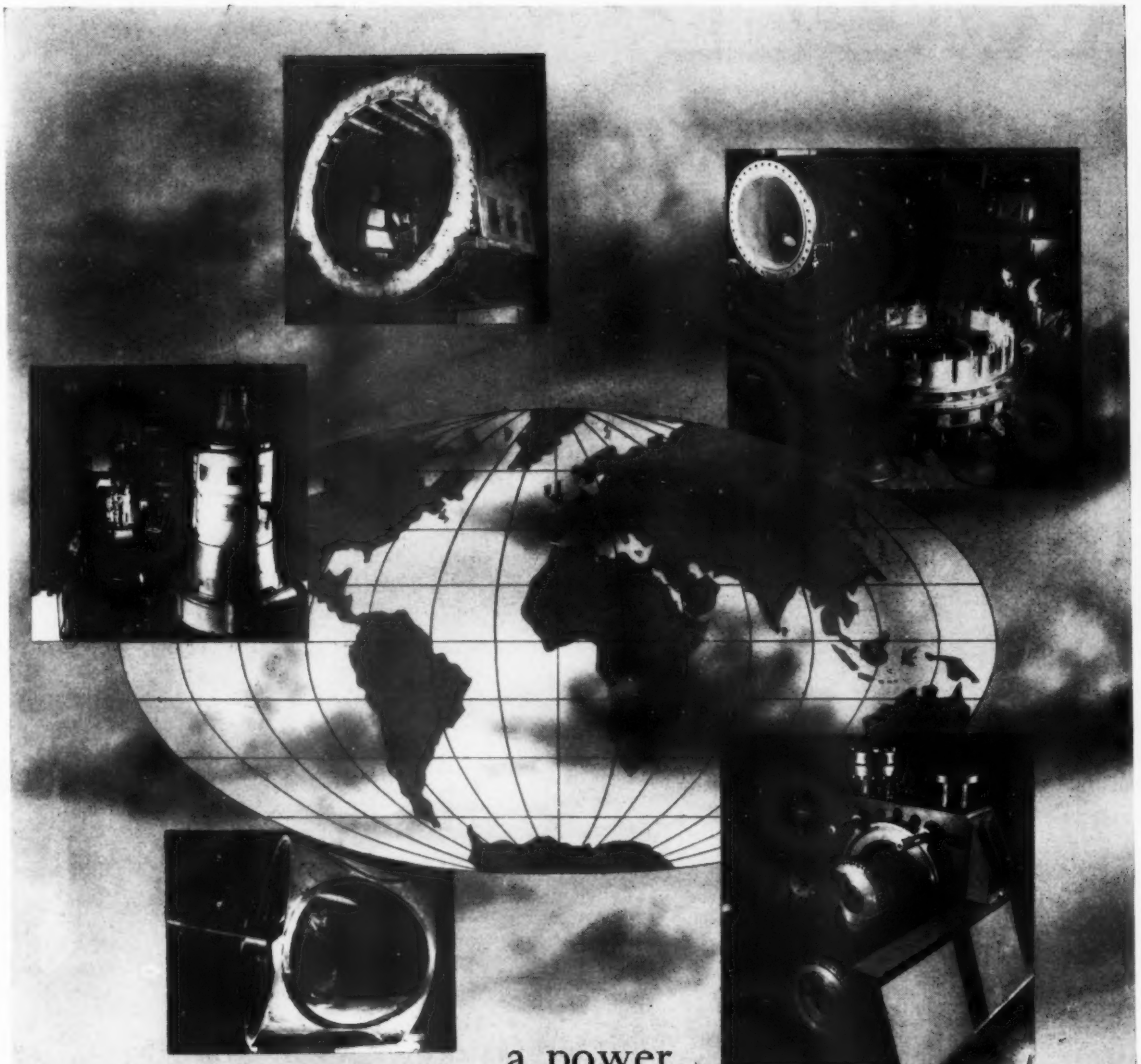
W. A. RUNCIMAN. Absorption and fluorescence spectra of ions in crystals.

D. WEST. Mesonic atoms.

Price £3 3*s*. (21*s*. to Members), postage 2*s*.

Separate articles at 7*s*. 6*d*. to 10*s*. 6*d*., postage 6*d*.

THE PHYSICAL SOCIETY · 1 Lowther Gardens, Prince Consort Road, London, S.W.7



HARLAND

CENTRIFUGAL PUMPS

ELECTRIC MOTORS & GENERATORS

COMPLETE HYDRO-ELECTRIC PLANT

HYDRAULIC DESCALING SYSTEMS

ROTOVALVES

a power for progress

In the minds of responsible engineers throughout the world Harland is a name which means thoroughly sound and reliable workmanship and impeccable design . . . a name, indeed, which symbolises power for progressive development.

THE HARLAND ENGINEERING CO LTD ALLOA SCOTLAND

LONDON AND EXPORT SALES OFFICES: HARLAND HOUSE 20 PARK STREET W1

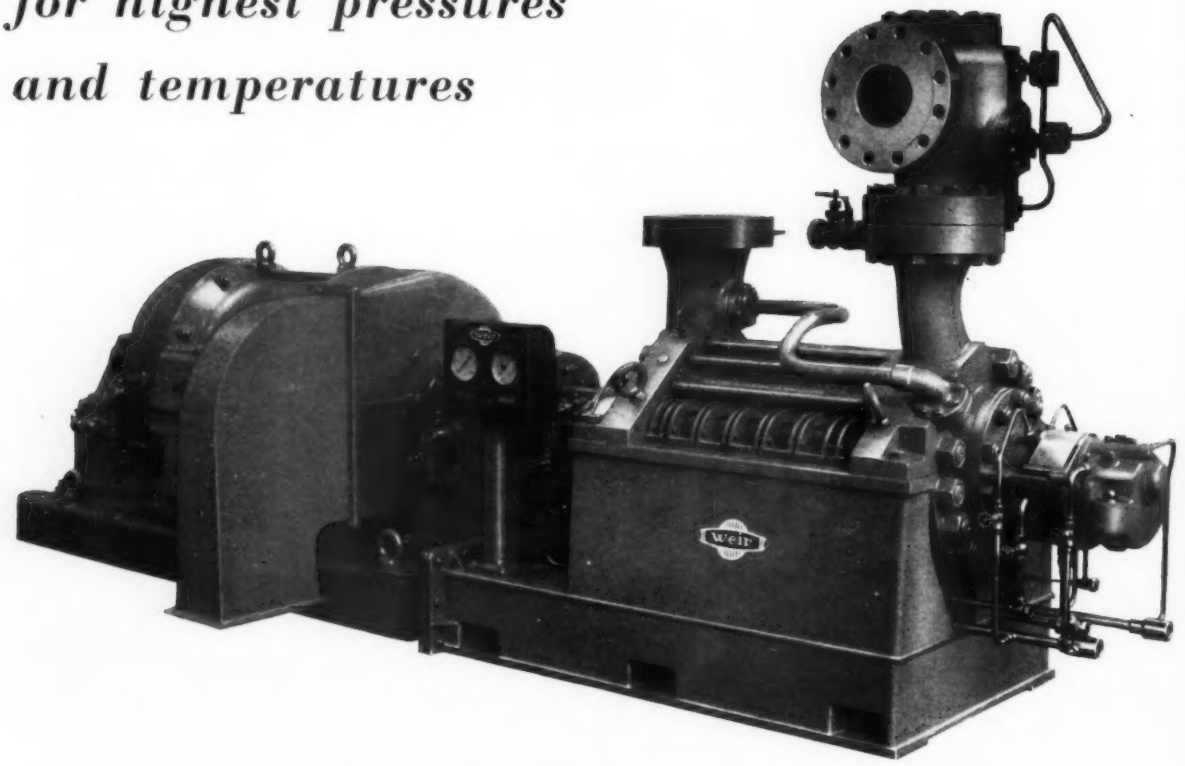
Branches in BRISTOL · GLASGOW · LEEDS · NEWCASTLE · NOTTINGHAM · TIMPERLEY (Cheshire) · WOLVERHAMPTON & OVERSEAS

Tick **No 20** on reply card for further details

Weir

ELECTROFEEDERS

for highest pressures and temperatures



meet every requirement of modern power station practice. They are inherently stable, unaffected by large temperature changes, in perfect hydraulic balance, and have effectively cooled glands. In design and construction, Weir Electrofeeders are based on unrivalled technical and practical experience. We specialise in boiler feeding and can advise on all power plant auxiliaries and type of pump most suitable.

Weir

FEED REGULATORS, FEED HEATERS, DEAERATORS
REGENERATIVE CONDENSERS, EVAPORATORS, ETC.

G. & J. WEIR LTD.
CATHCART · GLASGOW

stands for dependable self-priming

this is the type BG - an efficient vertical SP glandless pump

features for efficiency

only one moving part - the impeller

no mechanical seals

no packing

no stuffing box

no close clearances

* the originators of the successful self-priming principle were LaBour – whose pumps are still unequalled for long life and dependability

LABOUR PUMPS

BRITISH LABOUR PUMP CO LTD BLUNDELL ST LONDON N7 Tel: NORTH 6601-4

Tick **No 22** on reply card for further details

Butterfield

LIQUID NITROGEN STORAGE VESSELS

For low temperature work in nuclear research

*** TESTS CONDUCTED ON A 300 GALLON VESSEL SHOW AN EVAPORATION RATE OF ONLY ·66°/₀ EVERY 24 HOURS**

Butterfield Stainless Steel (Mild Steel Jacketed) Storage Vessels of 300 gallons capacity and upwards, are now employed in a number of Nuclear projects. Their duty is holding supplies of liquid nitrogen to be used for two purposes . . . that of cooling down both the plant for liquefying hydrogen and the hydrogen itself. Liquid hydrogen, in turn, is required for many problems in nuclear research.

AS FABRICATORS to the United Kingdom Atomic Energy Authorities, Butterfields have supplied or are now at work on Storage Vessels such as the 300 gallon type illustrated and larger capacities, for the following: *Ministry of Supply. Nuclear Physics Research Laboratory, Liverpool University. University of Birmingham. Royal Society Mond Laboratory, Cambridge. Rolls-Royce Limited. The Plessey Company. The Butterley Company. Conseil Européen pour la Recherche Nucléaire. U.K.A.E.A. Research Establishment, Aldermaston. Standard Telephones & Cables Ltd.*

We are equipped with Weld X-Ray Plant, materials testing and microscopic examination facilities for any required class of work

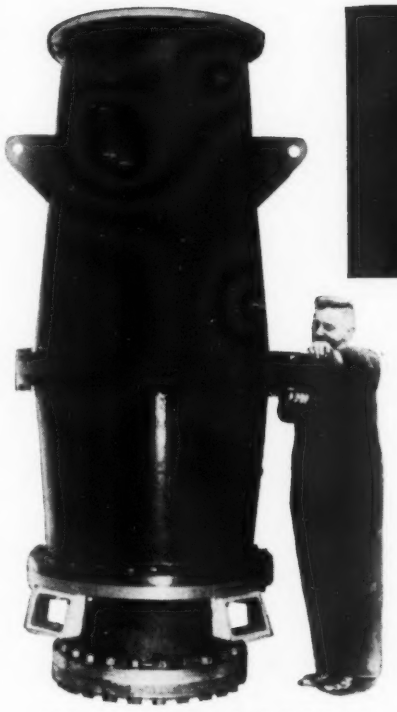
please mark all enquiries relating to this advertisement as follows: N/P/3

W. P. Butterfield Limited P.O. Box 38 Shipley Yorkshire Tel. 52244 (8 lines)

Branches: LONDON Tel HOLborn 2455 (4 lines) BIRMINGHAM Tel EAS 0871 & EAS 2241 BRISTOL Tel 27905 LIVERPOOL Tel Central 0829 MANCHESTER Tel Blackfriars 9417 NEWCASTLE-ON-TYNE Tel 23823 GLASGOW Tel Central 7696 BELFAST N.I. Tel 57343 DUBLIN Tel 73475 & 79745

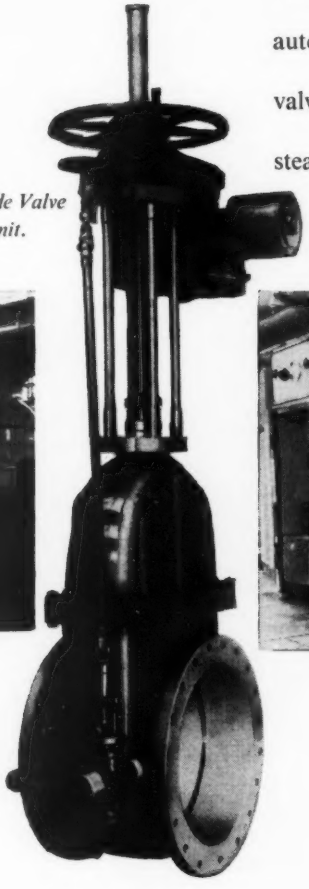
Tick **No 23** on reply card for further details

HOPKINSONS' equipment at CALDER HALL



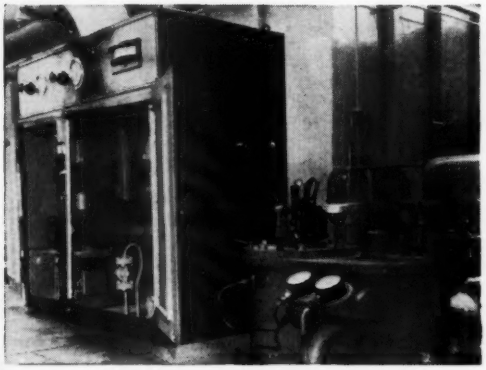
20 in. bore Deadweight Relief Valve. The largest Safety or Relief Valve ever built by Hopkinsons.

For the power station of the United Kingdom Atomic Energy Authority at Calder Hall, our valves and fittings have been supplied in very large quantities including valves ranging from ¾ in. to 28 in. bore, electrically-operated parallel-slide valves, desuperheating equipment, relief valves, combined stop and isolating valves, automatic exhaust valves, "Uniflow" valves, non-return valves, "Nolos" steam traps, centrifugal oil purifiers etc.



26 in. bore Parallel-slide Valve with electric control unit.

Centrifugal Purifier for continuous purification of turbine lubricating oil. Photograph by courtesy of the United Kingdom Atomic Energy Authority.



Desuperheater control cubicle, with mechanically-operated 8-way control valve and electrically-operated 2-way control valve.
Photograph by courtesy of the United Kingdom Atomic Energy Authority.

HOPKINSONS LIMITED • HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET • STRAND • W.C.2

TALBOT STEAD TUBE CO. LIMITED · GREEN LANE · WALSALL · A TI COMPANY

Julie takes her first faltering steps
into a world that will prove more and more exciting
as her interests develop.
She is growing up in a world
in which standards of living are constantly improving,
a world in which the magician's wand is electricity,
abundant supplies of electric power.

That is the vista opening out
with the beginning of the atomic power age.
An ever increasing number of power stations
turning more and more electricity into the grid
will bring incalculable benefits to us all.
Much has yet to be done before these atomic stations are all on load,
but the results to date prove
that the grander concept is well within the reach of the
engineering and allied skills of this country.
Talbot Stead supply in large quantities the steel tubes
without which the power stations cannot function.
These tubes are made and manipulated to the most exacting specifications,
but the work done so far, although immense in amount,
is well within the resources of the Company.
Talbot Stead will gladly co-operate with contractors
concerned with even more ambitious schemes.

Talbot Stead TUBES FOR ATOMIC ENERGY

Talbot Stead have been awarded contracts to supply the following reactor components:—

BRADWELL NUCLEAR POWER STATION:

C. A. Parsons & Co. Ltd.: *Short Charge Plugs; Absorber Rods; Fuel Element Support Assemblies; Control Rod Standpipe Plug Assemblies· Control Rod Standpipes; Charging Standpipes; Neutron Source Assemblies; Control Rod Channel Gags; Control Rods.*

A. Reyrolle & Co. Ltd.: *Burst Slug Detector Tubing.*

HUNTERSTON NUCLEAR POWER STATION:

The General Electric Co. Ltd.: *Control Rods; Distance Tubes; Charge/Discharge Tubes.*

MANUFACTURERS OF: CARBON, ALLOY AND STAINLESS STEEL TUBES · BI-METAL TUBES · 'METICA' METAL CLAD CARBON AND GRAPHITE TUBES · 'METIOR' SANITARY PIPE FITTINGS · MACHINED FLANGES AND COMPONENT PARTS · 'FORJEND' STAINLESS WELDING FITTINGS · CARBON, ALLOY AND STAINLESS DRAWN AND GROUND BARS AND WIRE

TBW/18

Tick **No 26** on reply card for further details

BY APPOINTMENT TO H.M. THE QUEEN
SUPPLIERS OF FIRE EXTINGUISHERS
THE PYRENE COMPANY LIMITED

facing new fire problems in the sphere of nuclear power

The Pyrene Company, with its unrivalled facilities for research, keeps ahead of changing industrial techniques, and is constantly developing the means to overcome the new fire risks they involve. As makers of the world's most comprehensive range of fire-fighting equipment The Pyrene Company can give you invaluable and impartial advice on any fire protection problem—it is yours for the asking.

We are proud to have given advice on fire protection — and supplied major fire-fighting equipment — for most British atomic centres already constructed. Consult Pyrene Fire Engineers and ensure maximum protection for invaluable plant, and human lives too.

The Pyrene Company has supplied fire-fighting equipment to

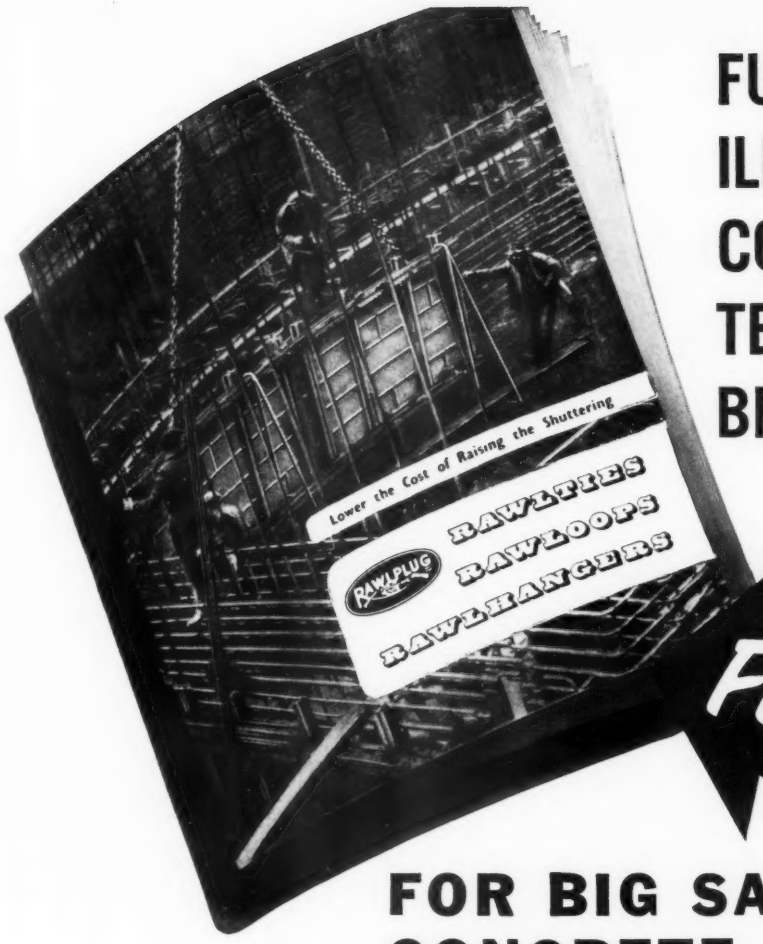
ALDERMASTON
CALDER HALL
CAPENHURST
DOUNREAY
FOULNESS
HARWELL
SPRINGFIELD
WINDSCALE

Pyrene TRADE MARK FIRE FIGHTING EQUIPMENT

THE PYRENE COMPANY LIMITED

(Dept. NP.3) 9 Grosvenor Gardens, London, S.W.1
Telephone: VICtoria 3401
HEAD OFFICE & WORKS: BRENTFORD, MIDDLESEX
CANADIAN PLANT: TORONTO

Tick No 27 on reply card for further details



FULLY ILLUSTRATED COMPREHENSIVE TECHNICAL BROCHURE

FREE!

FOR BIG SAVINGS IN CONCRETE FORMWORK

If concrete is your business you will find this latest Rawlplug Company publication of great value and interest. It is packed with practical, down-to-earth information on shuttering problems, together with details of Rawlties, Rawloops and Rawlhangers. May we send you a copy? Apply on your letterheading, send business card or state trade or profession.

Lower the cost of raising the shuttering with RAWLTIES · RAWLOOPS · RAWLHANGERS

These popular Fixing devices are designed to facilitate the speedy erection, striking and re-erection of formwork for all types of concrete work. This is achieved by providing anchorages to which the Shuttering can be Fixed and struck easily and quickly. They have many applications in Civil Engineering and Building construction for all types of buildings and in docks, reservoirs, airports, railways, bridges, silos, power stations, harbours, dams, sewage schemes, oil refineries bunkers, water towers, etc. In fact, wherever formwork is required for concrete. They minimise the use of scaffolding and obviate the use of through bolts. They form a positive contribution towards savings in timber, steel, time and manpower, with a consequent saving in building costs. They are extremely strong, simple and adaptable.

THE RAWLPLUG CO. LTD., CROMWELL RD., LONDON, S.W.7

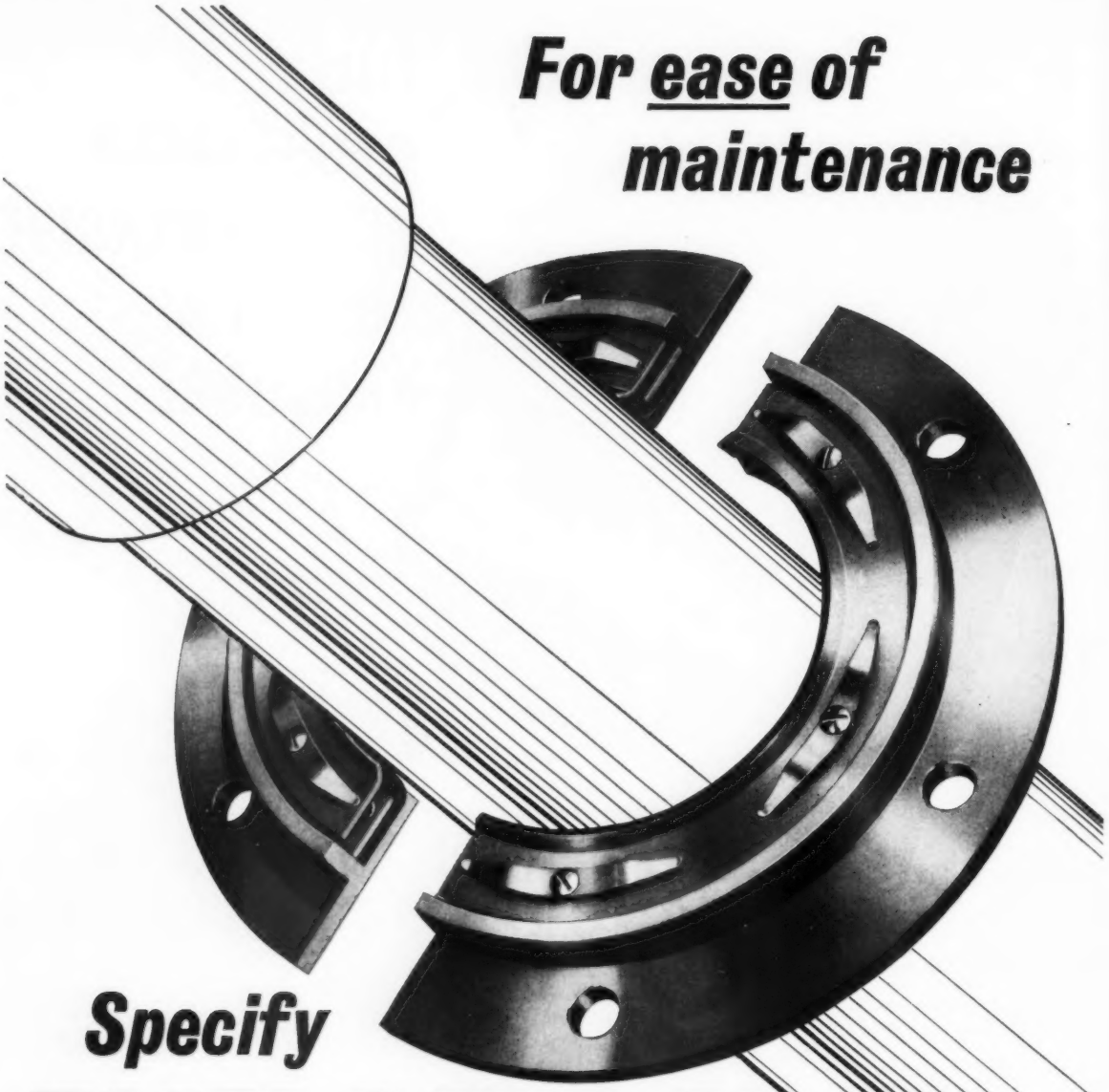
The World's Largest Manufacturers of Fixing Devices

RAWLPLUG

8502

Tick **No 28** on reply card for further details

For ease of maintenance



Specify

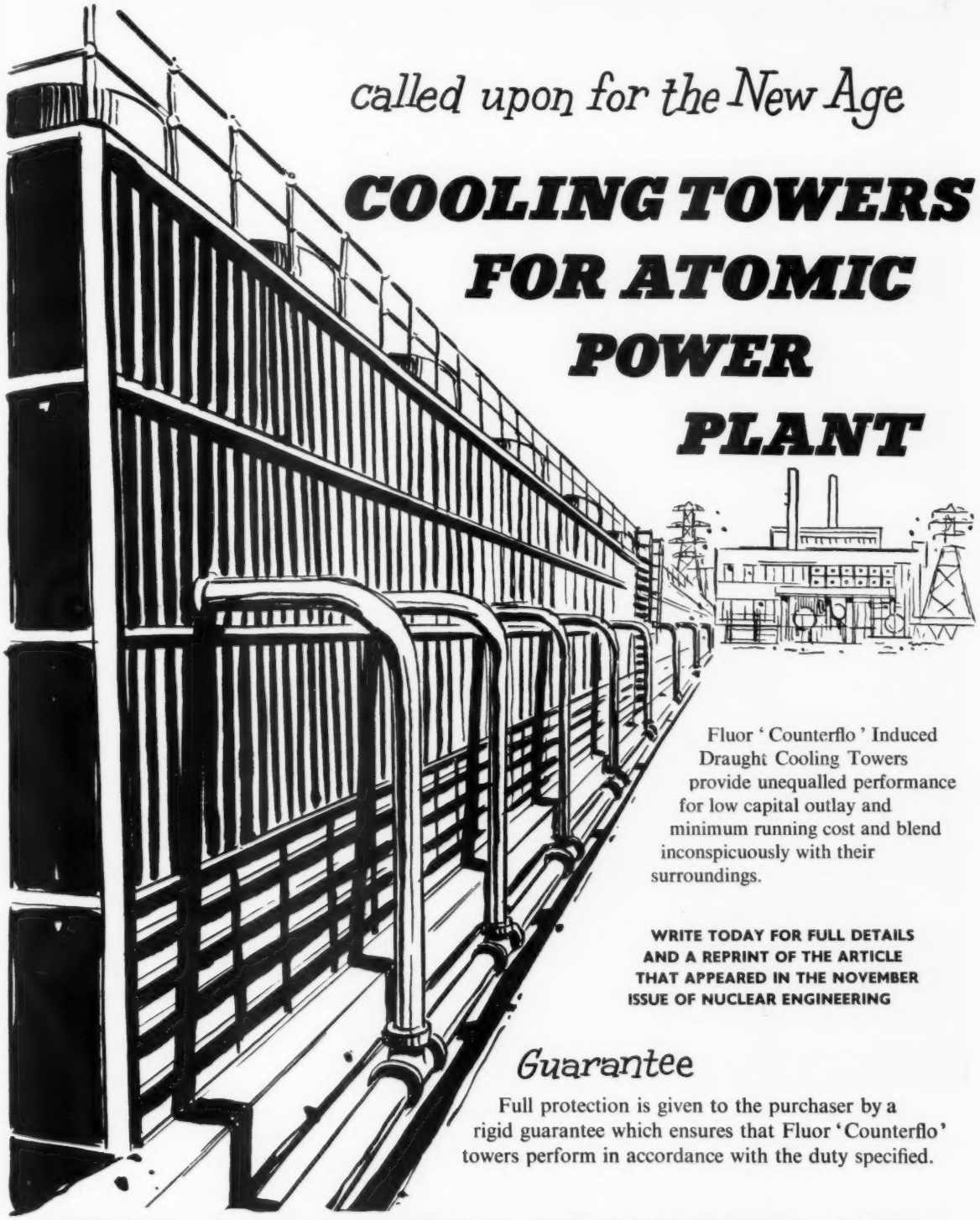
WESTON

SPLIT SEALS

CHARLES WESTON & CO. LTD. Irwell Bank Works · Douglas Green · Pendleton · Salford 6

Telephone: Pendleton 2857-8-9; Telex 66-255; Birmingham Midland 6952; London Holborn 0414; Telex 2-2682

A28



called upon for the New Age

COOLING TOWERS FOR ATOMIC POWER PLANT

Fluor ' Counterflo ' Induced Draught Cooling Towers provide unequalled performance for low capital outlay and minimum running cost and blend inconspicuously with their surroundings.

WRITE TODAY FOR FULL DETAILS AND A REPRINT OF THE ARTICLE THAT APPEARED IN THE NOVEMBER ISSUE OF NUCLEAR ENGINEERING

Guarantee

Full protection is given to the purchaser by a rigid guarantee which ensures that Fluor 'Counterflo' towers perform in accordance with the duty specified.

HEAD WRIGHTSON PROCESSES LTD.

TEESDALE HOUSE 24-26 BALTIC ST LONDON ECI

OFFICES AT: P.O. Box 1595 **SYDNEY** · P.O. Box 1034 **JOHANNESBURG** · P.O. Box 2608 **CALCUTTA** and 603 Royal Bank Buildings **TORONTO 1**

Associates in the U.S.A.: The Fluor Products Company · Los Angeles · New York · Chicago · Tulsa, etc.

P2884

Tick **No 30** on reply card for further details

A machine shop specially established for machining graphite under "Clean Conditions" is now in operation at our Hayes Works. This new department supplements our already extensive facilities for machining commercial graphite and is fully equipped with specialised plant for high precision work. It is capable of producing all types of graphite components for nuclear purposes.

GRAPHITE MACHINING

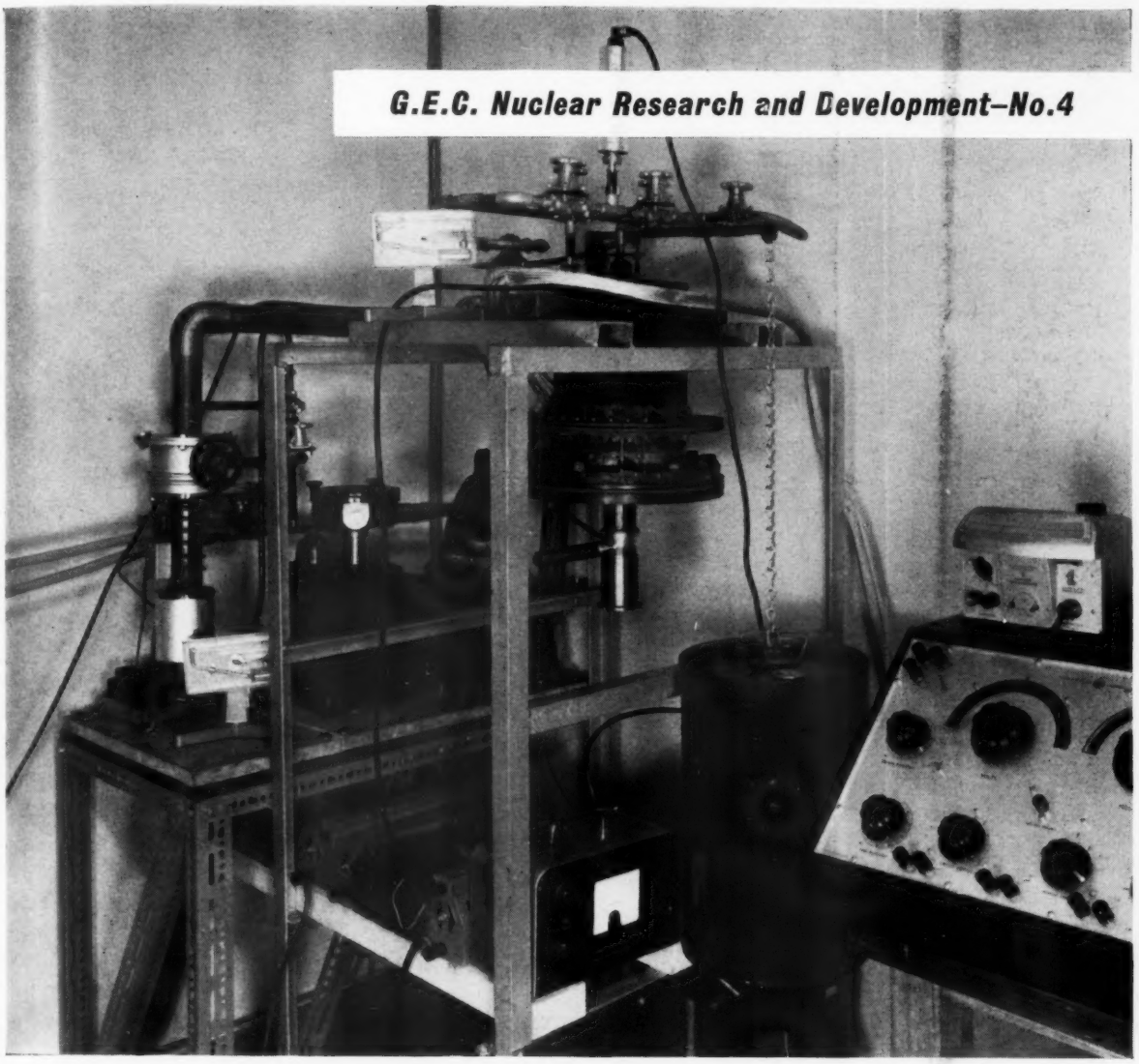
These photographs show the graphite for the NATURAL URANIUM GRAPHITE MODERATED EXPONENTIAL EXPERIMENT at Imperial College, London being machined in the new department. Further facilities for precision machining of full production quantities under "Clean Conditions" are now being installed.

Powell Duffryn

CARBON PRODUCTS LIMITED

DELANIUM
CARBON & GRAPHITE

SPRINGFIELD ROAD, HAYES, MIDDLESEX
TELEPHONE: HAYES 3994



G.E.C. Nuclear Research and Development—No.4

Uranium-to-can Heat Transfer

In a nuclear power reactor metallurgical considerations impose a limit on the temperatures that can be allowed in the uranium fuel rods. At the same time it is essential, for efficient heat transfer to the gas, that the can should be as hot as possible. It is thus necessary to determine the temperature drop that will occur between the centre and the surface of a fuel element.

The temperature drop between the centre and surface of the uranium is calculable by straightforward methods, but at the uranium/can interface a further drop takes place since the metal faces are not perfectly smooth. This can be determined only by experiment.

At the Erith laboratories of the G.E.C. the apparatus pictured above is used to measure the temperature drop as a function of surface temperature, for a variety of uranium surface finishes and with different gas fillings in the cans. One end of a cylindrical rod of canning material is heated, and heat flows along the cylinder, through a uranium test piece and into a second length of canning material, while thermocouples measure the temperature distribution along the heat path.

The results obtained facilitate the design of more efficient fuel elements and also make it possible to predict the temperatures that will prevail in the individual components under all possible conditions.

G.E.C.

Atomic Energy Division

THE GENERAL ELECTRIC CO. LTD · MAGNET HOUSE · KINGSWAY · LONDON · W.C.2.

A239

Reproduced by courtesy of C. A. Parsons & Co. Ltd.

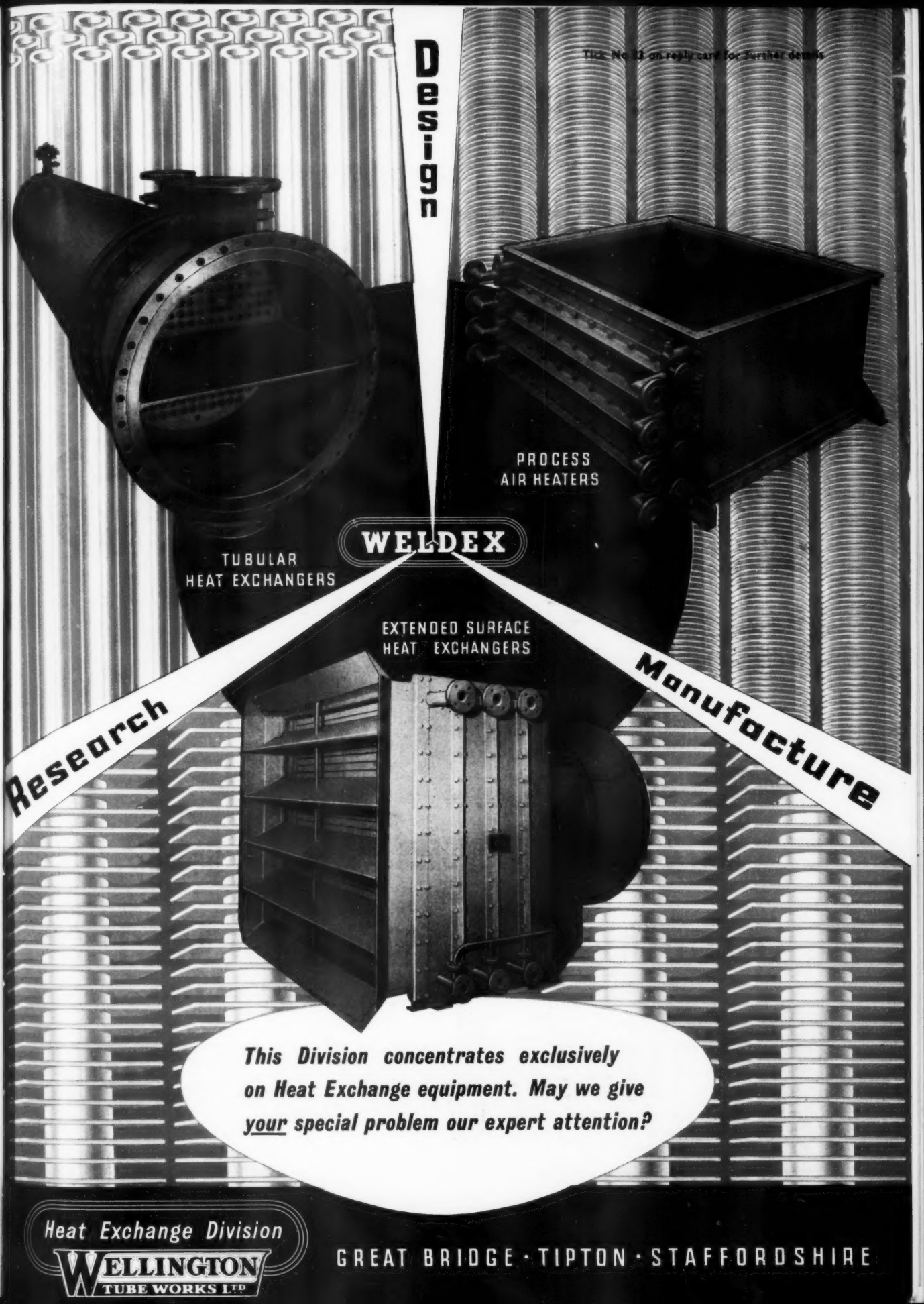
A typical example of an all-welded Outer Stator Casing, weighing 57 tons, manufactured in our works for a 120 MW Turbo-Generator

For all types of Heavy Platework and Steel Fabrications . . .

T.B. PEARSON & SONS LTD.

Wincomblee Road, Walker, Newcastle upon Tyne, 6 • Telephone: Wallsend 64081-2-3

Tick No 23 on reply card for further details



This Division concentrates exclusively on Heat Exchange equipment. May we give <u>your</u> special problem our expert attention?

Heat Exchange Division

WELLINGTON TUBE WORKS LTD

GREAT BRIDGE · TIPTON · STAFFORDSHIRE

Tick **No 34** on reply card for further details

to strain,

or to filter

diesel **FUEL** or **PETROL**...

lubricating,

edible, or cutting **OILS**...

AIR... LIQUIDS... POWDERS... DUSTS... GASES

interpose an INTERMIT

filter, strainer, or gauze...

INTERMIT limited

specialists in the design and production of filters, strainers, and ventilators to specification or by collaborative research and development.

Enquiries to:
INTERMIT LIMITED · BRADFORD STREET · BIRMINGHAM 5
Phone: Midland 7961

Member of the BIRFIELD Group

BIRFIELD INDUSTRIES LIMITED · STRATFORD HOUSE · LONDON · W1

Tick No 35 on reply card for further details

A COMPLETE PRECISION & PROTOTYPE NUCLEAR ENGINEERING SERVICE

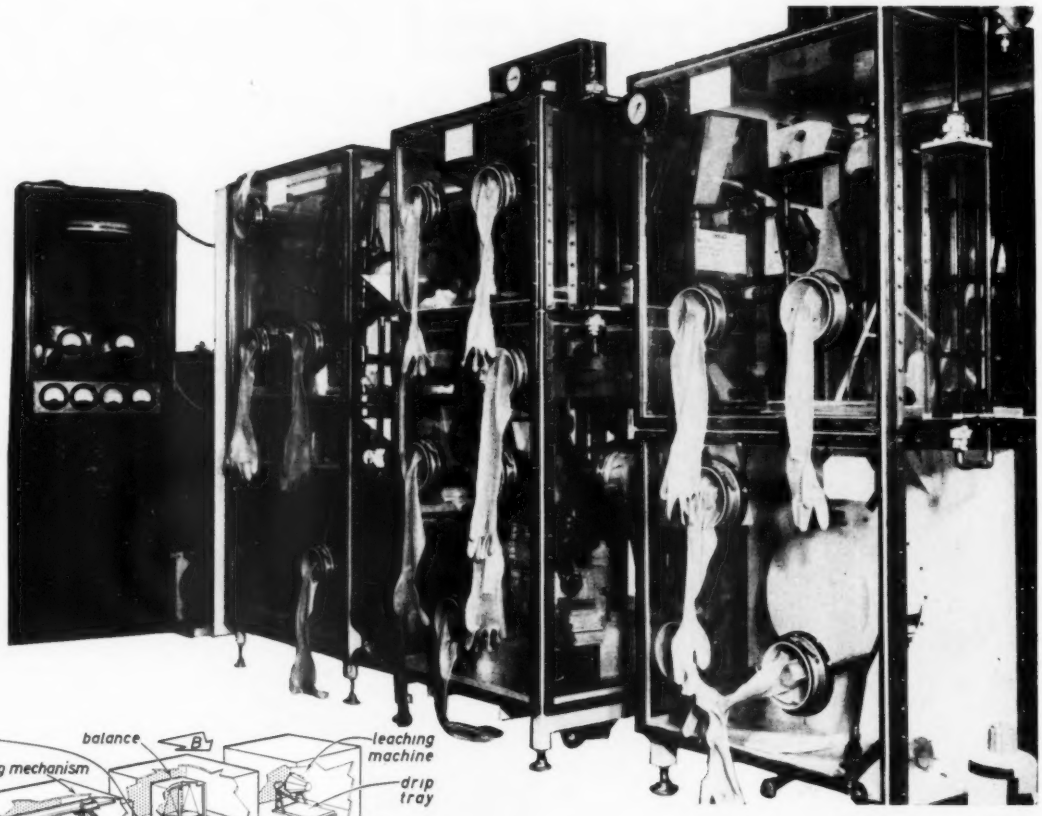
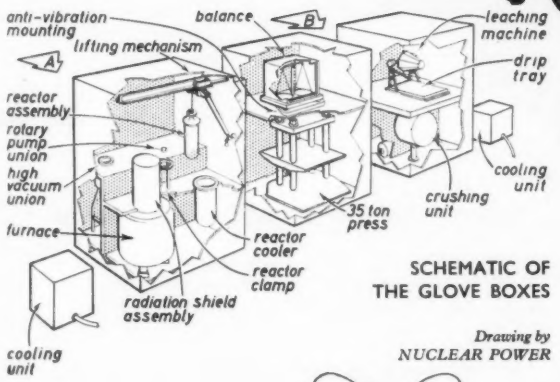


Photo by courtesy of A.E.R.E.



SCHEMATIC OF THE GLOVE BOXES

Drawing by NUCLEAR POWER

A SUITE OF GLOVE BOXES FOR EXPERIMENTAL PRODUCTION OF U-233 METAL

- Consulting engineers
- Designers and manufacturers of nuclear and specific prototype equipment
- Remote manipulation equipment
- Vacuum casting equipment
- High vacuum equipment
- Electronic engineers
- Radio frequency engineers
- Low temperature refrigeration
- Installation contractors

WESTERN DETAIL MANUFACTURERS LTD

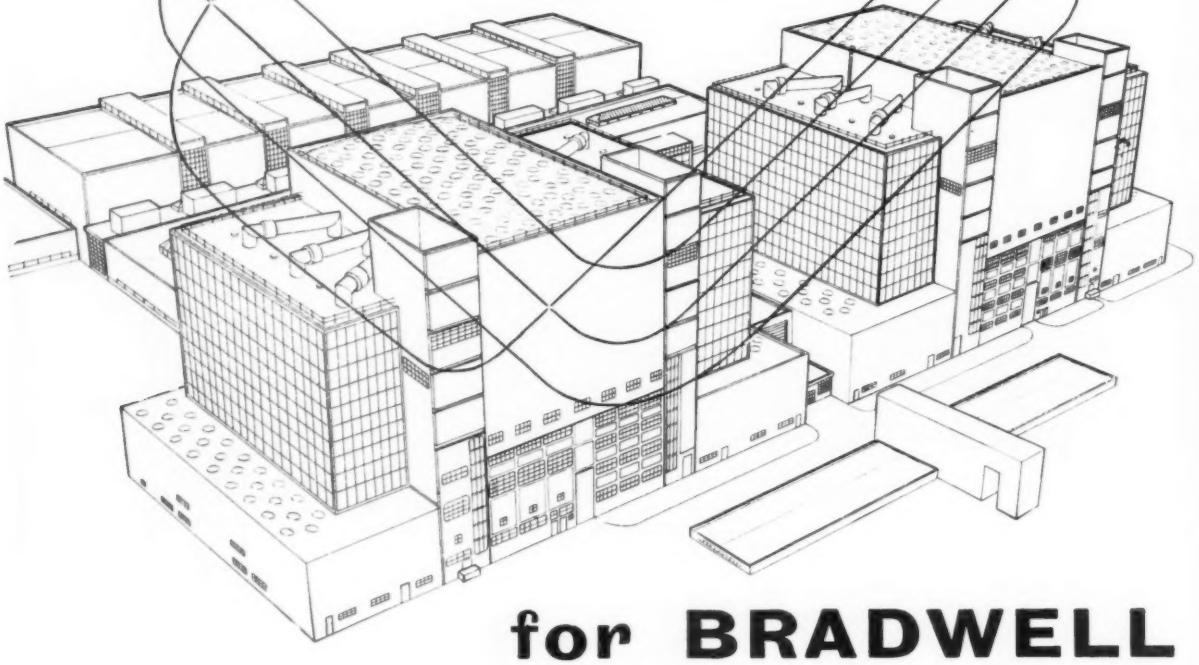
WESTERN WORKS, STAPLE HILL BRISTOL telephone 65-6141/42/43 cables and telegrams: Aries, Bristol, England

Tick **No 36** on reply card for further details

mancuna

mechanical filters

on the CO_2 by-pass and driers



for BRADWELL

The choice of Mancuna Dustex D.450 MK 111 B Filters for Bradwell Nuclear Power Station rests on the high degree of efficiency and 100% availability without any maintenance. This equipment is being supplied under contract to C. A. Parsons & Co. Ltd., a member of the Nuclear Power Plant Company Ltd.

mancuna **ENGINEERING LIMITED**

DENTON, MANCHESTER. ***Phone: DENTON 3965 (5 lines)***

London Office

59 VICTORIA ROAD, SURBITON, SURREY. ***Phone: ELMbridge 9793***

Heating · Ventilating · Filtration · Air Conditioning · Humidity Control, etc.

Tick **No 37** on reply card for further details

300 MEGAWATTS AT BRADWELL, ESSEX

A Greater Britain through Nuclear Power

A greater Britain because her industry can draw upon hundreds of thousands of kilowatts of productive electrical power without burning a pound of coal or a pint of oil as fuel. A greater Britain because Bradwell, despite the exciting technical advance it represents, is a commercial atomic power station and underlines the remarkable British lead in the practical application of nuclear energy. The Nuclear Power Plant Company is proud to be entrusted with this great contract by the Central Electricity Authority.

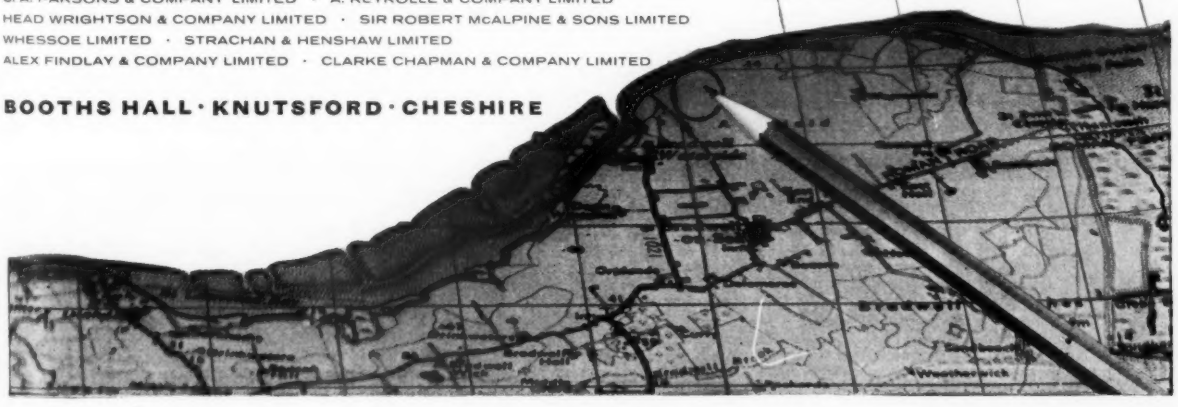
N.P.P.C. combines the resources of eight specialist companies whose individual skills are planned and co-ordinated into a unified team capable of undertaking the construction of complete nuclear power stations throughout the world.

NPPC

THE NUCLEAR POWER PLANT COMPANY LIMITED

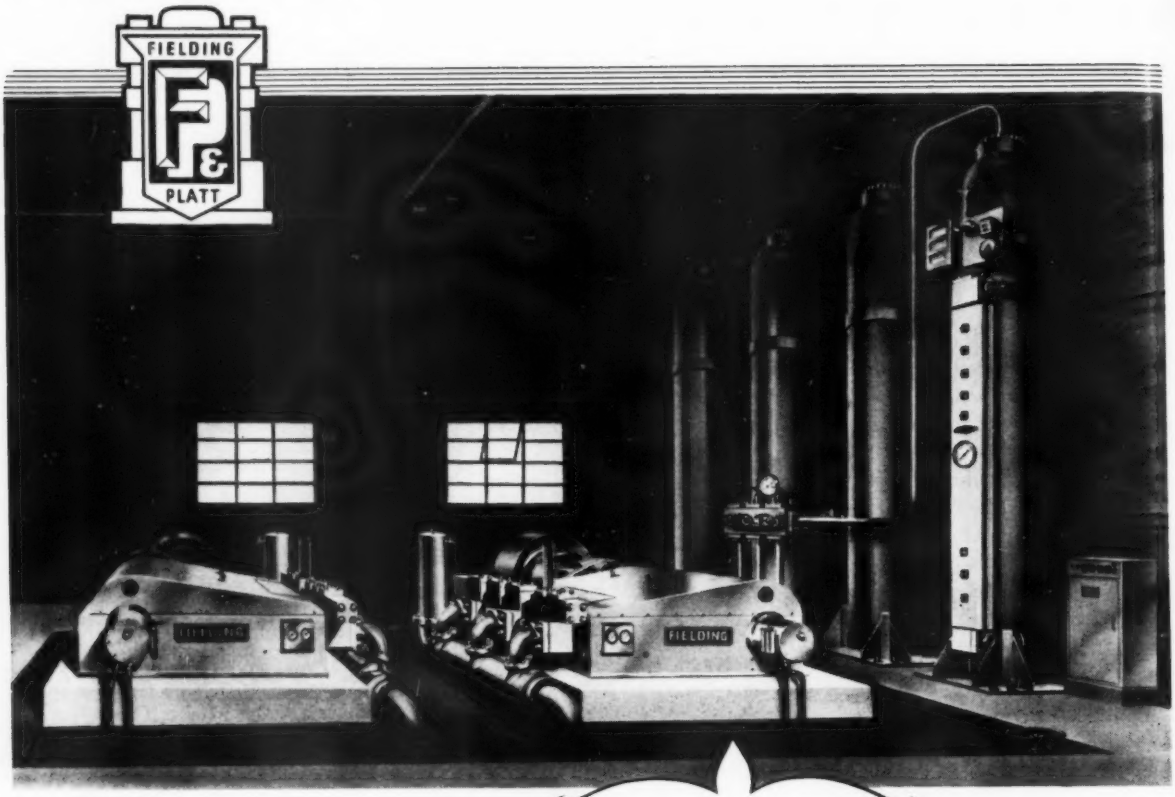
C. A. PARSONS & COMPANY LIMITED · A. REYROLLE & COMPANY LIMITED
HEAD WRIGHTSON & COMPANY LIMITED · SIR ROBERT McALPINE & SONS LIMITED
WHESSOE LIMITED · STRACHAN & HENSHAW LIMITED
ALEX FINDLAY & COMPANY LIMITED · CLARKE CHAPMAN & COMPANY LIMITED

BOOTHS HALL · KNUTSFORD · CHESHIRE



TGA NPI
A37

Tick **No 38** on reply card for further details



A Typical Illustration of a

FIELDING

HYDRAULIC POWER HOUSE INSTALLATION

comprising High Pressure Hydraulic Pumps and Electronic Liquid Level Controlled Pistonless Air Hydraulic Accumulator.

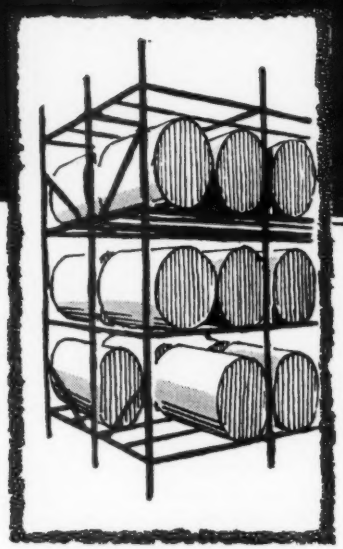
WE SPECIALISE IN THE MANUFACTURE OF AN EXTENSIVE RANGE OF MODERN HIGH PRESSURE PUMPS AND AIR HYDRAULIC ACCUMULATORS, AND CAN SUPPLY COMPLETE INSTALLATIONS.

FIELDING & PLATT LTD

ENGINEERS ATLAS WORKS

GLOUCESTER • ENGLAND

K/FP. 16



UNISTRUT

STANDARDISED

SPEED AND ECONOMY IN PURPOSE-MADE SUPPORT STRUCTURES

Unistrut components—steel channel for framing and a comprehensive range of specific-purpose components—are standardised round a brilliantly simple, ultra-rapid self-locating nut assembly. Whatever the requirements of the individual job, Unistrut enables you to build a correct, economical support structure *at the minimum on-site cost*. It's a matter of fundamental design. Please write for details to the address below.

FOR RACKING, PIPING AND ELECTRICAL INSTALLATIONS, AND ALL FRAMING APPLICATIONS

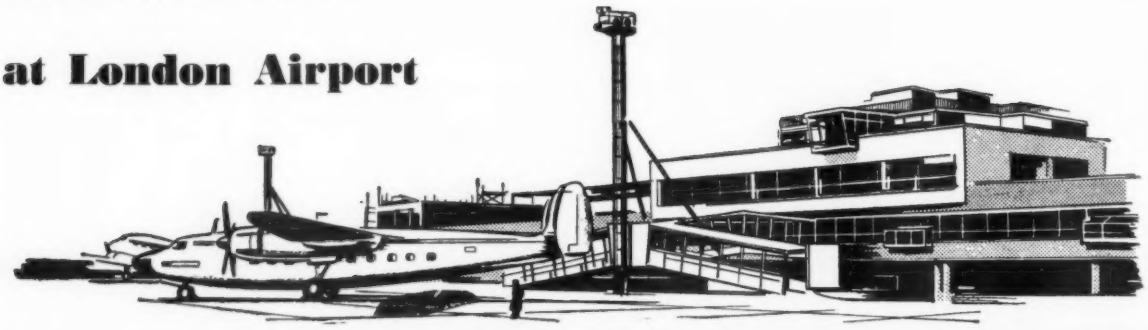
UNISTRUT DIVISION OF SANKEY-SHELDON LTD., DEPT. NP6, 46 CANNON STREET, LONDON, E.C.4

Telephone: CITy 4477. Telegrams: Sankeshel, Cannon-London.

UNI 975

Tick **No 40** on reply card for further details

at London Airport



CORRUSTEEL

ARMOURED
CABLE

wandleside
of
wandsworth

Illustration shows "CORRUSTEEL" Armoured Cable in the Main Feeder Trunking at London Airport's new building. Electrical Contractors, The L.E.B. Contracting Section, Chelsea Manor Street, S.W.3

WANDLESIDE CABLE WORKS LTD. 106 GARRATT LANE · WANDSWORTH · LONDON S.W.18

Telephone: BATtersea 2273-4

Telegrams: "Wandleside, London"

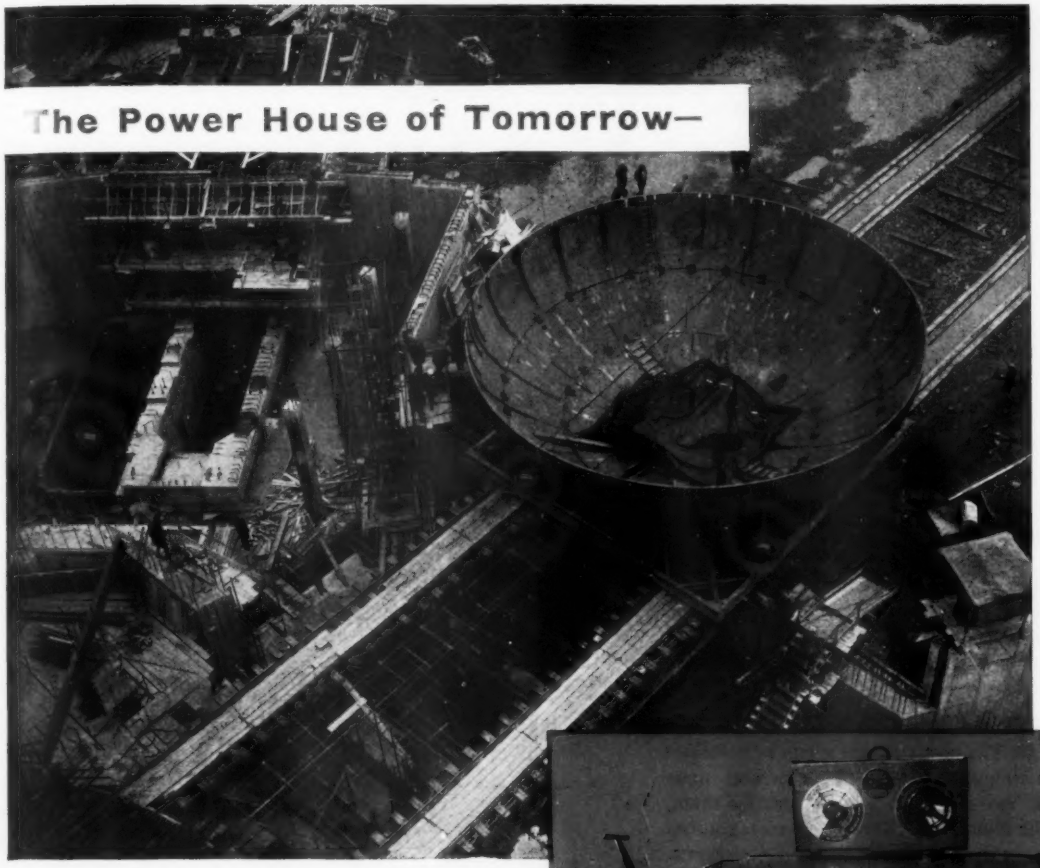
One of **FALKS** Group.

WANDLE BRITISH MADE CABLE

LONDON OFFICE: 21 Fitzroy St., London, W.1. BELFAST OFFICE: Dublin Rd., Belfast, N. Ireland. BRADFORD OFFICE: 19 Union St., Bradford, Yorks

Tick **No 41** on reply card for further details

FIRST IN THE FIELD—AND STILL IN THE LEAD



BUILT WITH THE POWER UNIT OF TODAY

LINCOLN ELECTRIC COMPANY LIMITED, the largest manufacturers of D.C. Welding Equipment in the United Kingdom proudly announce that they have been privileged to supply a large number of their SAE 300 amp and SAE 600 amp Motor Generators (to provide current for Class 1 pressure vessel welding) to Messrs. John Thompson (Wolverhampton) Limited, who are constructing the pressure vessels at the 275 MW Nuclear Power Station being built by the A.E.I.–John Thompson Nuclear Energy Co. Ltd. for the Central Electricity Authority at Berkeley, Gloucestershire.

The Lincoln SAE 300 and SAE 600 Motor Generators are motor-driven welders with self-indicating dual continuous control and a selection of any type and size of arc for every job. The self protected motor permits sustained operation at a high current.

Ultimately 80 of these famous Lincoln Electric Company Limited's power units will be providing current for high class welding on the Berkeley Nuclear Power Station project.

For full details of the Lincoln Electric range of D.C. Generator units—from the S.A. 150 amp workshop 'Junior' to the SAE 900 amp for large Lincolnweld installations please write to:

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920 (5 lines) 4581 (5 lines)

E24

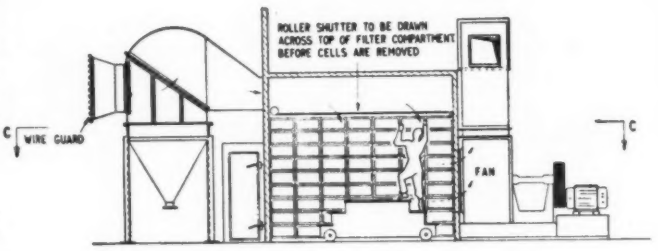
Tick **No 42** on reply card for further details

Problem at Maralinga

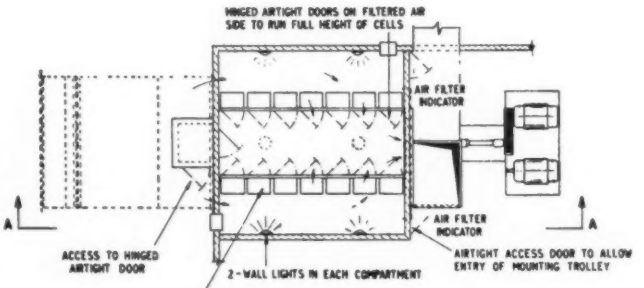
THE PROBLEM Maralinga lies in some of Australia's most desolate territory—a desert area where airborne dust concentrations are high. Here is the Ministry of Supply atomic weapons range. In this rugged climate air conditioning and ventilating are of vital importance—particularly in the laboratories, where every dust particle entering might be a hazard to the operation of delicate instruments. This was one of the problems facing the Consulting Engineer.

THE SOLUTION The biggest single group of buildings was that containing laboratory buildings and some administrative. Two stage filtration was decided upon, as shown in the illustrations. The second stage consists of Vokes Kompak filters with composite elements. Having passed through a cyclone type dust separator, to remove the large dust particles, the Vokes Kompak filters take over. They remove the remaining 8% of dust, particle sizes between 12 and 50 microns and 98% of all dust particles between 12 and 1.5 microns. To maintain continuity of operation during cleaning a standby filter is provided.

THE VOKES K.600 KOMPAK FILTER The K.600 Kompak, a 600 c.f.m. filter, can be built into banks of any capacity and has a cheaply and easily replaceable standard element of 'Filterdown' fabric, but can be fitted with a composite element for special applications. Like other Vokes air conditioning filters, it offers high efficiency, ease of servicing, low pressure drop, and minimum air velocity through the filter medium.
In the case discussed here, clean air was the problem. But whenever you are concerned with air, fuel, lubricating or hydraulic oil, there's a Vokes filter designed to do the job properly. Details are available in our illustrated literature which will gladly be sent on request.



SECTION A-A


HINGED AIRTIGHT DOORS ON FILTERED AIR SIDE TO RUN FULL HEIGHT OF CELLS
AIR FILTER INDICATOR
A
A
AIR FILTER INDICATOR
ACCESS TO HINGED AIRTIGHT DOOR
2-WALL LIGHTS IN EACH COMPARTMENT
AIRTIGHT ACCESS DOOR TO ALLOW ENTRY OF MOUNTING TROLLEY
VOKES COMPOSITE 'KOMPAK' FILTER

PLAN ON C-C

Arrangement of two-stage filter for air inlet to central ventilation plant serving laboratory buildings.

VOKES

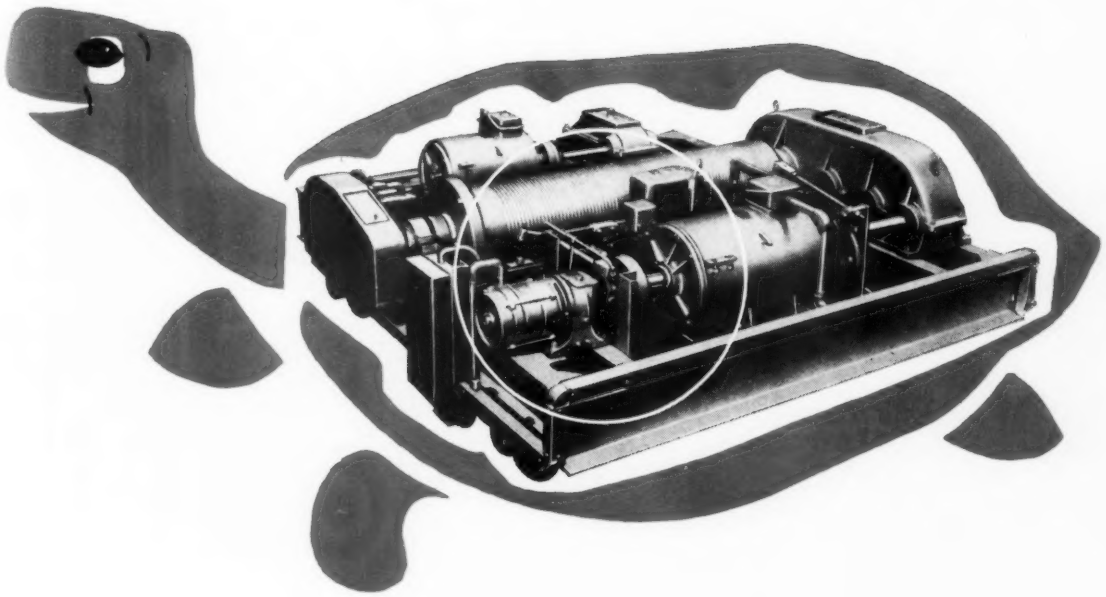
Pioneers of Scientific Filtration

VOKES LIMITED · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines). Telegrams and Cables: Vokesacess, Guildford, Telex. Telex: 13-535 Vokesacess, Gfd.

Vokes (Canada) Ltd., Toronto. Vokes (Australia) Pty. Ltd., Sydney Represented throughout the World

slowly but surely . . .



Slomax Creep-Speed Control

This system was developed to meet the need for a controlled creeping speed for all motions of cranes on A.C. supply where precise slow-speeds are required.

The success of this well-tried system, proved under arduous conditions lies in its extreme simplicity.

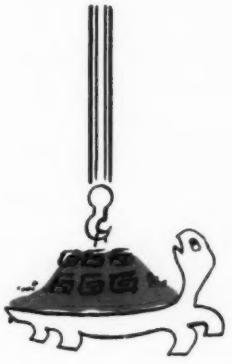
The device is entirely automatic and fool-proof.

The main motor is not energised when the creeping speed is in operation.

The operating circuits being electrically inter-locked, it is impossible for the main motor and the Slomax motor to operate simultaneously.

Slomax control permits an unlimited ratio between creeping and normal speeds, and whilst ten to one is usual, a ratio of fifty to one is not uncommon for specialised duties.

A further advantage is that where precise creeping speeds are required for specialised operations, the Slomax control will ensure a predetermined creeping speed, irrespective of the load on the hook.



THE WHARTON CRANE & HOIST CO. LTD.

REDDISH STOCKPORT ENGLAND

Phone: Heaton Moor 2227. Grams: "Gallant, Manchester." Code: Western Union

LONDON	Lincoln House, 296-302 High Holborn W.C. 1	Phone: Chancery 7911	Grams: Chancery 7911
SCOTLAND	Fisher-Baxter & Co., 140 West George Street, Glasgow C. 2	Phone: Douglas 1061-2-3	Grams: Fluorspar, Glasgow
MIDLANDS	A. R. Holland & Son, 89 Cornwall Street, Birmingham 3	Phone: Central 1457	Grams: Central 1457, Birmingham
SOUTH WEST	R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan	Phone: Penarth 1527	Grams: Penarth 1527
NORTHERN COUNTIES	Fisher-Baxter & Co., 140 West George Street, Glasgow C. 2	Phone: Douglas 1061-2-3	Grams: Fluorspar, Glasgow
NORTHERN IRELAND	General Engineering Products Ltd., 7/9 Great Patrick Street, Belfast.	Phone: Belfast 23743	Grams: Belfast 23743
EIRE and SOUTHERN IRELAND	Charles Nolan & Co., 2 Parker Hill, Lower Rathmines Road, Dublin	Phone: Dublin 93510	Grams: Dublin 93510
CANADA	Marshall Equipment Co. Inc., P.O. Box 88, 61 Victoria Avenue, Dorval Station, P.Q.	Phone: Melrose 1-3528	Grams: Marquipco, Montreal

REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD.

Tick No 44 on reply card for further details

Bailey's and Atomic Energy

1949 WINDSCALE PLUTONIUM PILES

1951 CAPENHURST DIFFUSION FACTORY

1953 CAPENHURST DIFFUSION FACTORY

1953 CALDER 'A' PRELIMINARY WORKS

1954 CALDER 'A' MAIN CONTRACT

1955 CAPENHURST DIFFUSION FACTORY

1956 CALDER 'B' MAIN CONTRACT

1957 BERKELEY NUCLEAR POWER STATION
A.E.I.-JOHN THOMPSON NUCLEAR ENERGY CO. LTD.

1957 WINDSCALE WORKS

N. G. BAILEY & CO., LTD.

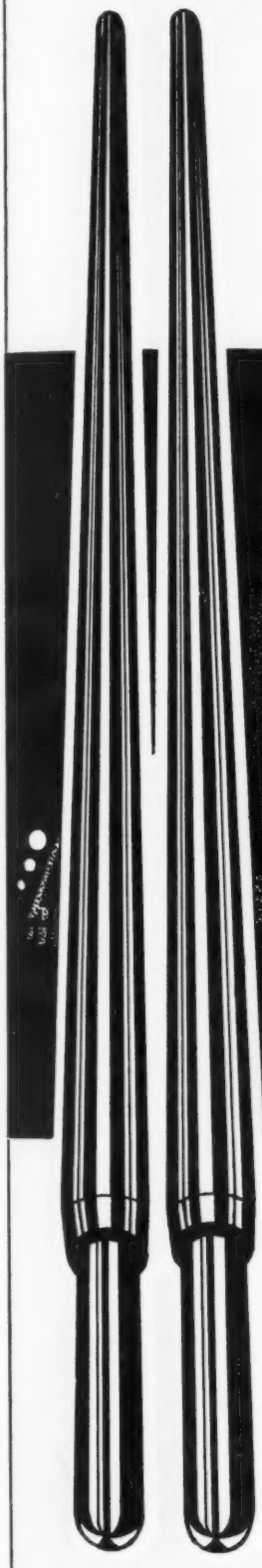
Electrical Engineers

BURLEY VALE WORKS, KIRKSTALL ROAD, LEEDS, 4

Phone: LEEDS 637854

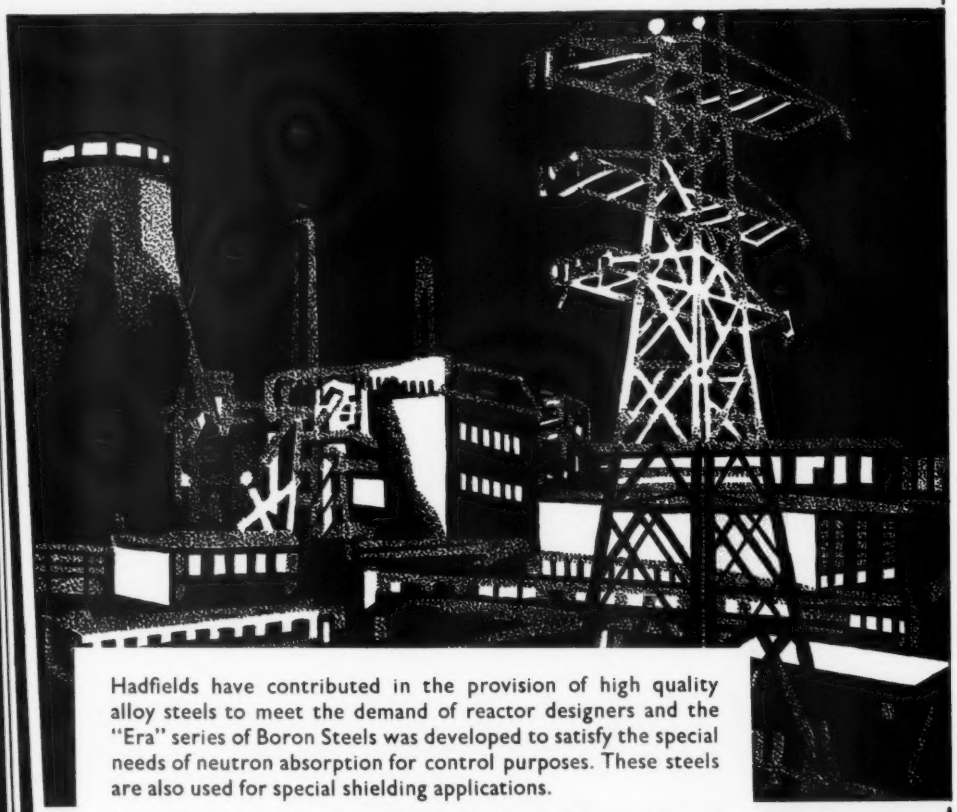
London *Persian Gulf* *Manchester*

A44



SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated



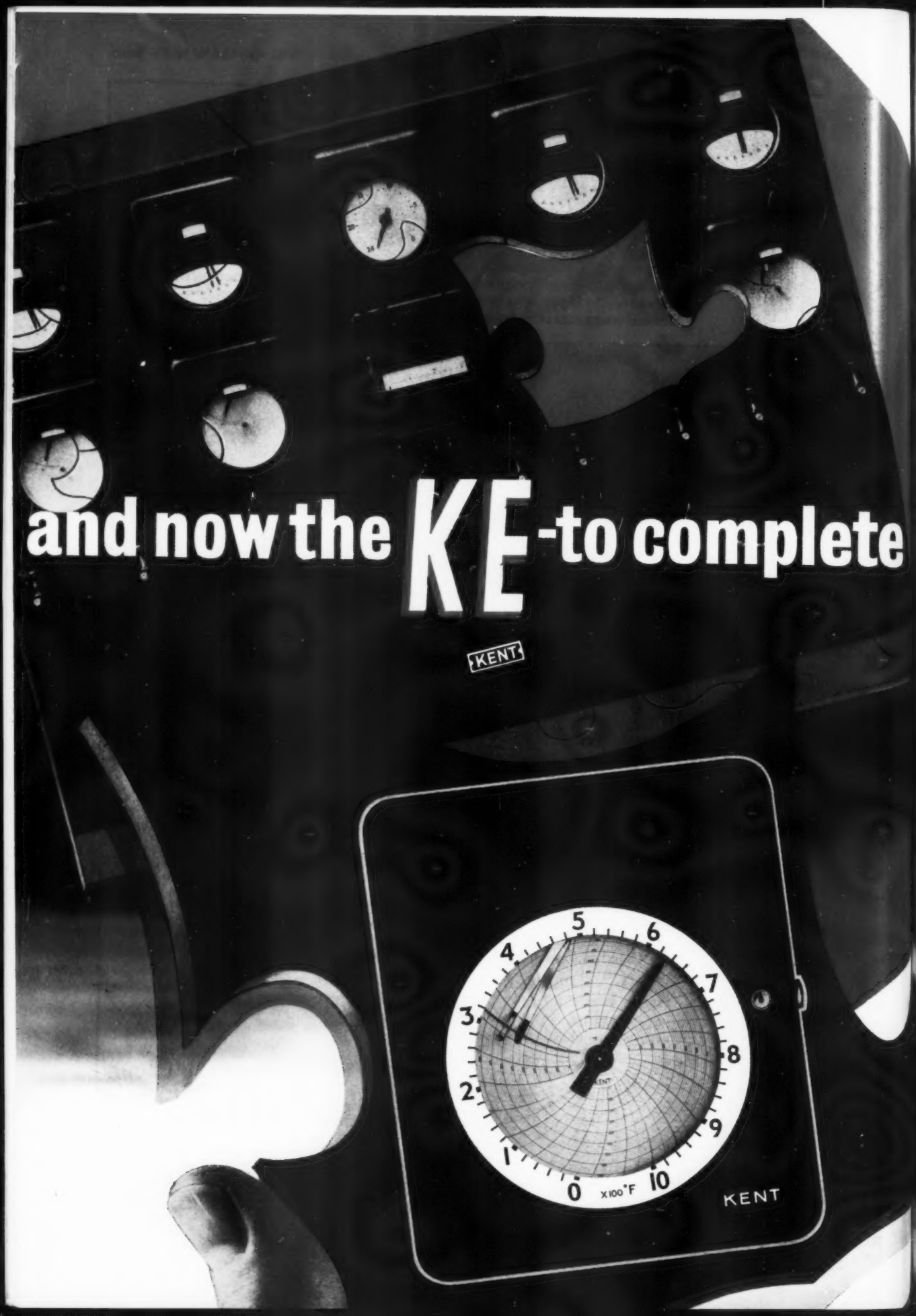
Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.


and now the KE-to complete t
KENT
KENT
X100°F
KENT

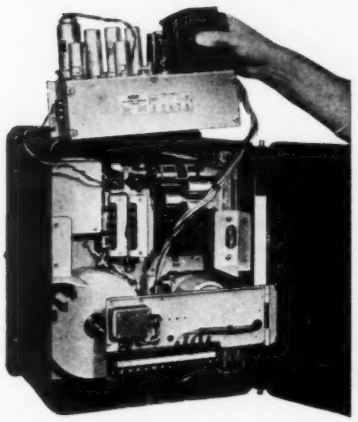
Tick **No 47** on reply card for further details

AN ENTIRELY NEW ELECTRONIC SELF-BALANCING INSTRUMENT

This outstanding new instrument is the answer to the demand for a universal potentiometric indicating/recording/controlling instrument in the now-familiar *Commander* style of presentation. At one stride it extends the *Commander* range, complying with British Standards on cases and charts, to embrace a whole new field of measurements. It makes possible complete *Commander* multi-instrument panels to suit virtually *any industrial measurement or control application*—panels of instruments which set a new standard for accuracy, reliability and range.

The *Commander KE*, released only after long development and extensive market research, incorporates many inherent advantages over similar self-balancing instruments. These include:

- A built-in device for the elimination of non-linearities from thermocouples and other non-linear primary elements—providing advantages for double-range instruments and enabling use with computers, standard integrators and linear re-transmission
- All-mains operation—no batteries—with continuous standardising



Rear view of KE instrument, showing how the amplifier can be withdrawn and placed on top of the case for checking and servicing

COMMANDER picture

- Two speeds of operation—2 seconds or 15 seconds for full-scale travel—built-in speed adjustment
- Accuracy $\pm\frac{1}{4}\%$ of maximum scale range
- Electric measuring system can be withdrawn without upsetting circuit wiring
- Built-in upscale/downscale drive for external circuit failure
- Choice of three amplifiers, using standard electronic components, catering for a wide range of input conditions, a.c. and d.c.
- Provision for including any of the KENT Mark 30 range of air-operated controlling units
- Full-scale range equivalent from 2mV to 2V d.c., from 5mV a.c., with provision for simple range-changing
- Plug-in units
- Simple zero-checking facilities

ENTIRE ASSEMBLY PLANNED FOR MAXIMUM ACCESSIBILITY AND MINIMUM MAINTENANCE

AVAILABLE AS RECORDERS AND AS RECORDER/INDICATORS

Two basic presentation units are at present available:
(a) Recorder only, with B.S. 11 in.-diameter chart
(b) Recorder with ring-scale indicator, as illustrated.

There are many other interesting and practical features of the *Commander KE* which you should investigate without delay—write now for Publication 993 or telephone Atomic Energy Contracts Dept., Luton 2440, Ext 193.

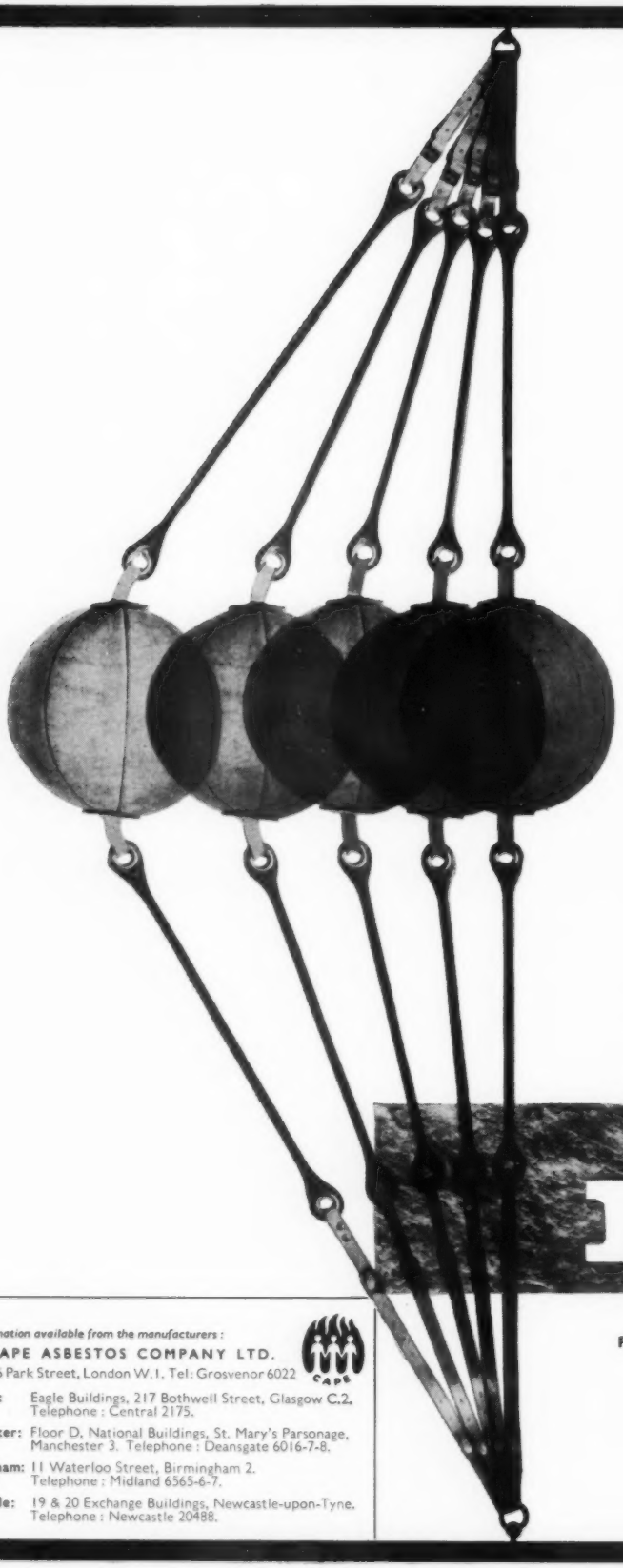
And remember — the KE is backed all along the line by KENT'S world-wide manufacturing, sales and service organization, with subsidiary companies, offices and distributors in most countries.

MASTERS OF INSTRUMENTATION

KENT

GEORGE KENT LIMITED · **LUTON** · **BEDFORDSHIRE** · **ENGLAND**

Factories, Subsidiary Companies, and Offices in London · Resolven · Hitchen · Toronto · Montreal · Vancouver Melbourne · Sydney · Johannesburg · Salisbury · Penang · Bangkok · Brussels · Krefeld · Vienna · The Hague



Rocksil

is

resilient

too

ROCKSIL—for either hot or cold insulation—has many important advantages to offer. Probably the most outstanding is its combination of strength with resilience—'rigid' resilience that absorbs impact and stands up well to considerable deflection of the surface it is protecting. In bonded slab form of various thicknesses and densities this makes Rocksil ideal for casing and structural insulation. It will not settle under continuous vibration even as loose infill. Rocksil is produced from natural Scottish rock and is odourless, chemically inert and sulphur-free, non-hygroscopic and rot-proof.

Rocksil Regd.

ROCK WOOL INSULATION

Full information available from the manufacturers:

THE CAPE ASBESTOS COMPANY LTD.
114 & 116 Park Street, London W.1. Tel: Grosvenor 6022

Glasgow: Eagle Buildings, 217 Bothwell Street, Glasgow C.2. Telephone: Central 2175.

Manchester: Floor D, National Buildings, St. Mary's Parsonage, Manchester 3. Telephone: Deansgate 6016-7-8.

Birmingham: 11 Waterloo Street, Birmingham 2. Telephone: Midland 6565-6-7.

Newcastle: 19 & 20 Exchange Buildings, Newcastle-upon-Tyne. Telephone: Newcastle 20488.

8259

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на каточке на противоположной стороне и отправьте к NUCLEAR POWER

請查詢問服務

在廣告上以有限的地方
來解釋一些專门技術 及它們的
効果 的確是有受限制的困难
要請求改善和進一些詳細的情形
就請將对頁的表格 取一號下來
將閱下有疑问的項目 用笔勾一下
即寄核子能工程處即可.

讀者サービス

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

1	26	51	76	101	126
2	27	52	77	102	127
3	28	53	78	103	128
4	29	54	79	104	129
5	30	55	80	105	130
6	31	56	81	106	131
7	32	57	82	107	132
8	33	58	83	108	133
9	34	59	84	109	134
10	35	60	85	110	135
11	36	61	86	111	136
12	37	62	87	112	137
13	38	63	88	113	138
14	39	64	89	114	139
15	40	65	90	115	140
16	41	66	91	116	141
17	42	67	92	117	142
18	43	68	93	118	143
19	44	69	94	119	144
20	45	70	95	120	145
21	46	71	96	121	146
22	47	72	97	122	147
23	48	73	98	123	148
24	49	74	99	124	149
25	50	75	100	125	150

March 1958

READER INFORMATION SERVICE

It is often difficult for advertisers to give all the technical details about their products in a limited amount of space. If you would like further information simply tick the appropriate numbers on the card opposite and mail to NUCLEAR POWER. *Also the following items not nnmbered*

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

1	26	51	76	101	126
2	27	52	77	102	127
3	28	53	78	103	128
4	29	54	79	104	129
5	30	55	80	105	130
6	31	56	81	106	131
7	32	57	82	107	132
8	33	58	83	108	133
9	34	59	84	109	134
10	35	60	85	110	135
11	36	61	86	111	136
12	37	62	87	112	137
13	38	63	88	113	138
14	39	64	89	114	139
15	40	65	90	115	140
16	41	66	91	116	141
17	42	67	92	117	142
18	43	68	93	118	143
19	44	69	94	119	144
20	45	70	95	120	145
21	46	71	96	121	146
22	47	72	97	122	147
23	48	73	98	123	148
24	49	74	99	124	149
25	50	75	100	125	150

March 1958

READER INFORMATION SERVICE

It is often difficult for advertisers to give all the technical details about their products in a limited amount of space. If you would like further information simply tick the appropriate numbers on the card opposite and mail to NUCLEAR POWER. *Also the following items not numbered*

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

1	26	51	76	101	126
2	27	52	77	102	127
3	28	53	78	103	128
4	29	54	79	104	129
5	30	55	80	105	130
6	31	56	81	106	131
7	32	57	82	107	132
8	33	58	83	108	133
9	34	59	84	109	134
10	35	60	85	110	135
11	36	61	86	111	136
12	37	62	87	112	137
13	38	63	88	113	138
14	39	64	89	114	139
15	40	65	90	115	140
16	41	66	91	116	141
17	42	67	92	117	142
18	43	68	93	118	143
19	44	69	94	119	144
20	45	70	95	120	145
21	46	71	96	121	146
22	47	72	97	122	147
23	48	73	98	123	148
24	49	74	99	124	149
25	50	75	100	125	150

March 1958

READER INFORMATION SERVICE

It is often difficult for advertisers to give all the technical details about their products in a limited amount of space. If you would like further information simply tick the appropriate numbers on the card opposite and mail to NUCLEAR POWER. *Also the following items not numbered*

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

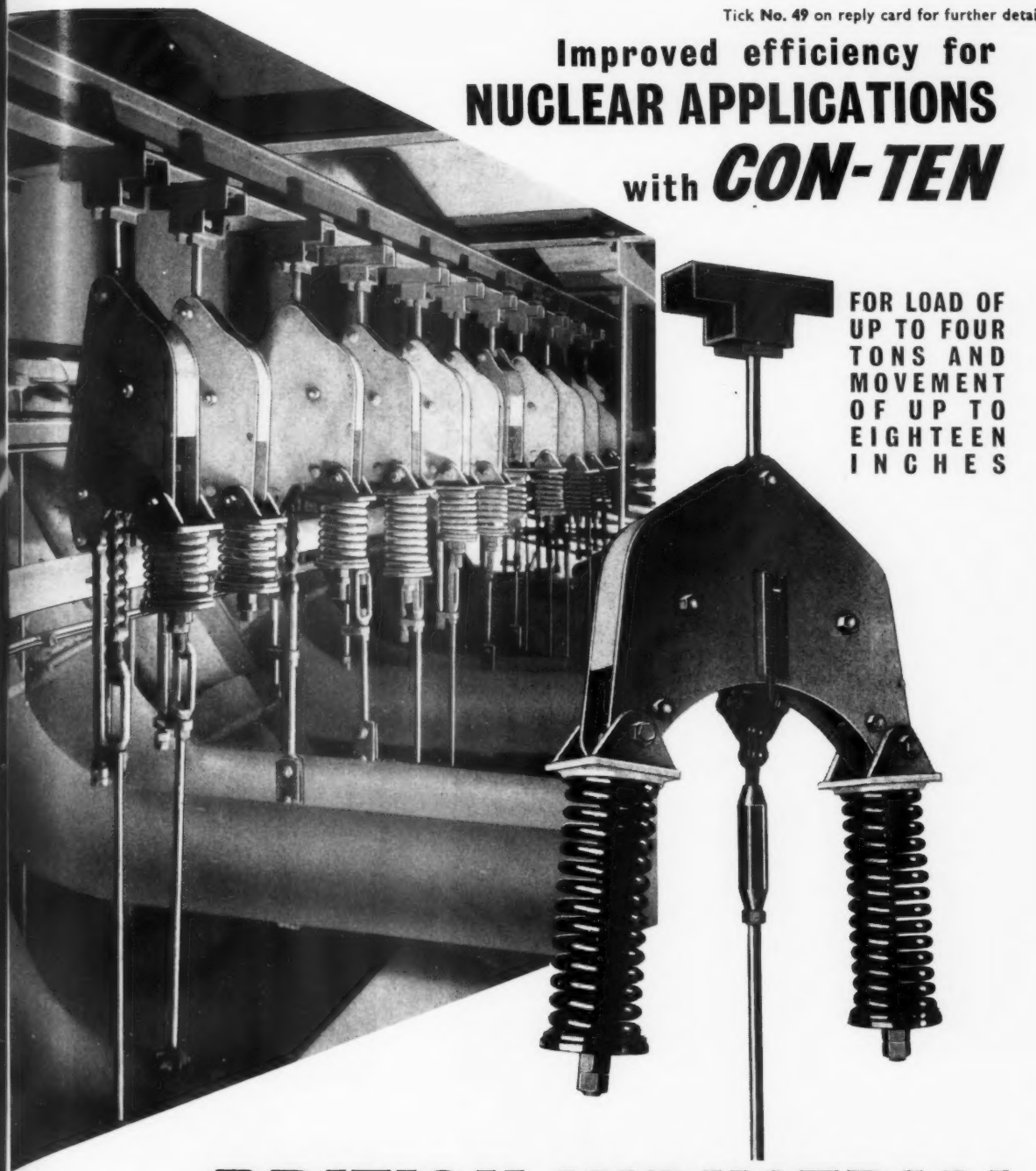
No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Tick No. 49 on reply card for further details

Improved efficiency for
NUCLEAR APPLICATIONS
with CON-TEN



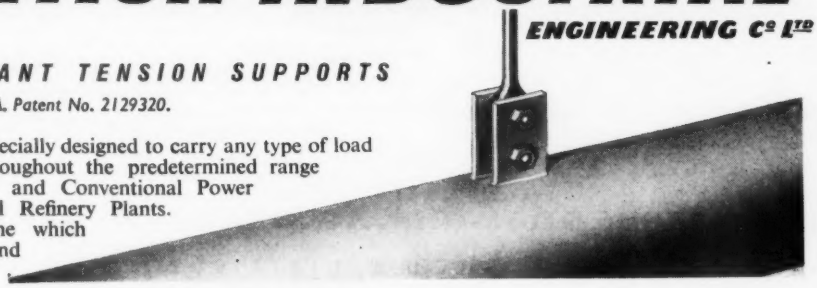
FOR LOAD OF UP TO FOUR TONS AND MOVEMENT OF UP TO EIGHTEEN INCHES

BRITISH INDUSTRIAL
ENGINEERING Co LTD

CON-TEN CONSTANT TENSION SUPPORTS

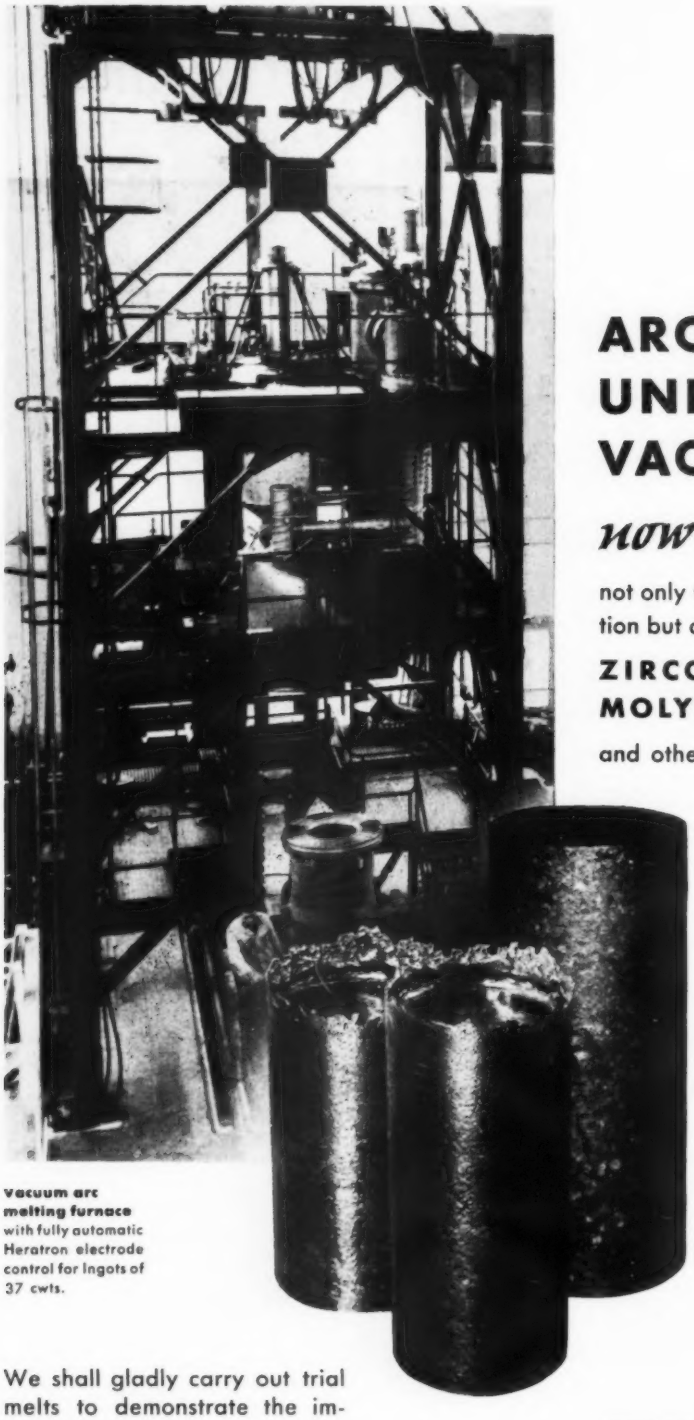
British Patent No. 474008. U.S.A. Patent No. 2129320.

" Con-Ten " Supports are specially designed to carry any type of load under constant tension, throughout the predetermined range of movement, for Nuclear and Conventional Power Stations, Chemical and Oil Refinery Plants. It is acknowledged as one which produces minimum friction and kinematic variation.



CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS. TEL: TIPTON 1222

Tick No. 50 on reply card for further details



Vacuum arc melting furnace with fully automatic Heratron electrode control for ingots of 37 cwts.

Heraeus

ARCMELTING UNDER VACUUM

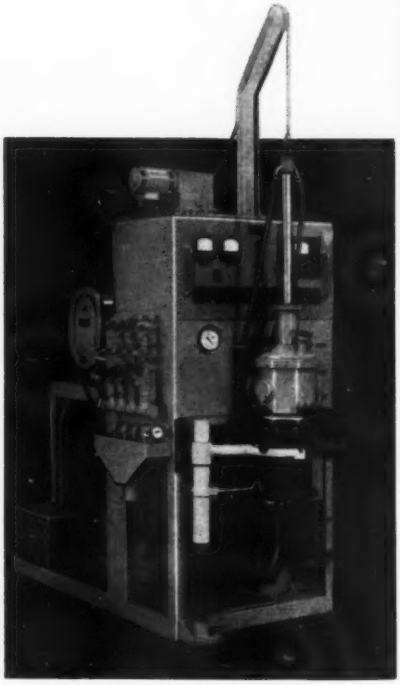
now economical

not only for Titanium production but also for **STEEL**

ZIRCONIUM
MOLYBDENUM

and other metals and alloys

We shall gladly carry out trial melts to demonstrate the improved quality achieved by this modern process.



Arcmelting furnace for smaller batches of all metals, alloys, carbides and borides

W. C. HERAEUS GMBH · ABT. HOCHVAKUUM · HANAU · GERMANY

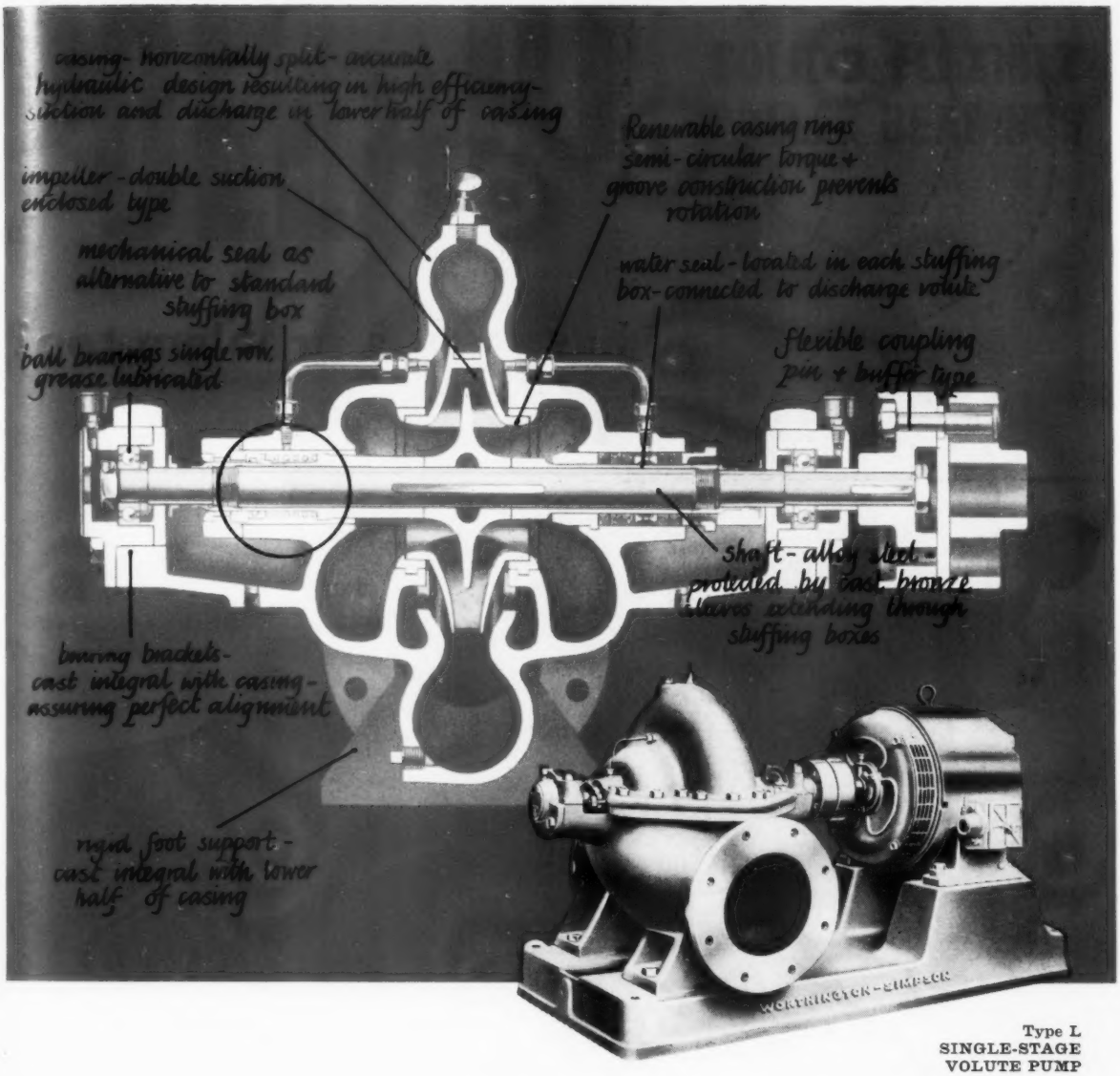
SOLE U. K. DISTRIBUTORS:

FLEISCHMANN (London) LTD, CHANCERY HOUSE, CHANCERY LANE, **LONDON W.C. 2**

Telephones: Holborn 7415 (8 lines)

Teleprinter: London 28816

A50


casing - horizontally split - accurate hydraulic design resulting in high efficiency - suction and discharge in lower half of casing
impeller - double suction enclosed type
mechanical seal as alternative to standard stuffing box
ball bearings single row grease lubricated
bearing brackets - cast integral with casing - assuring perfect alignment
rigid foot support - cast integral with lower half of casing
Renewable casing rings semi-circular torque + groove construction prevents rotation
water seal - located in each stuffing box - connected to discharge volute
flexible coupling pin + buffer type
shaft - alloy steel - protected by cast bronze sleeves extending through stuffing boxes
WORTHINGTON-SIMPSON

Type L
SINGLE-STAGE
VOLUTE PUMP

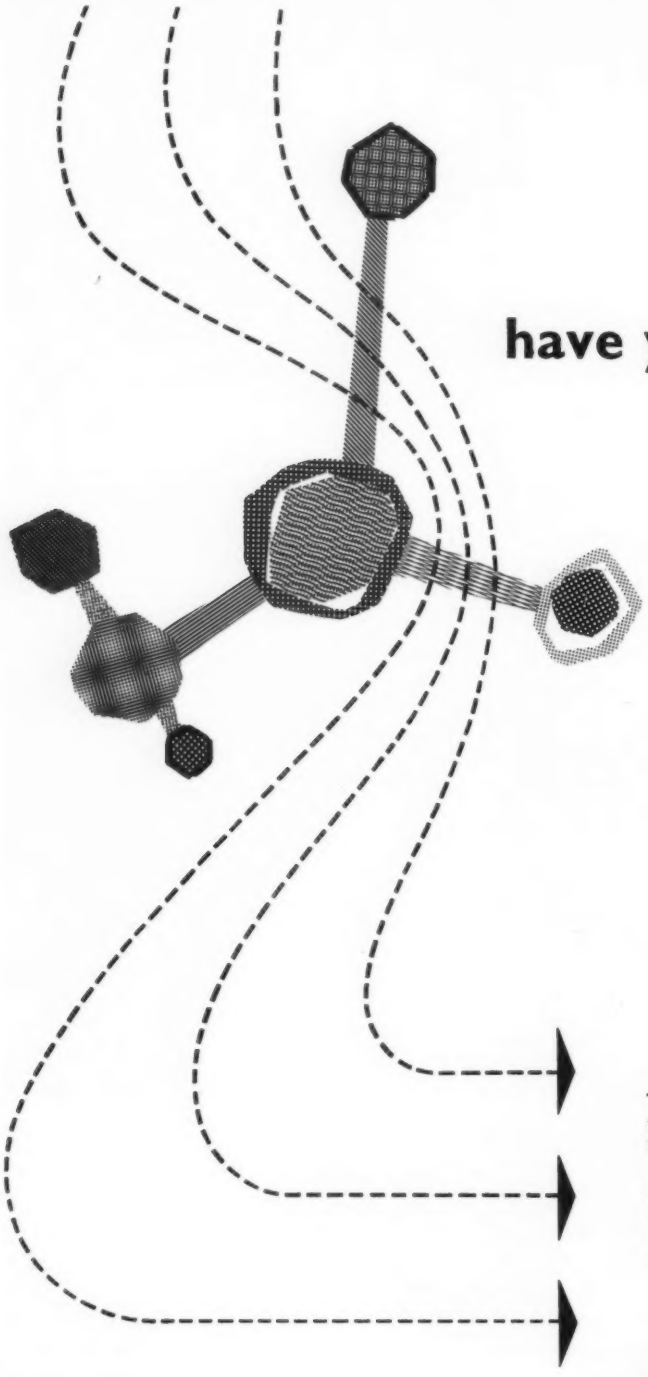
easy access to the interior

Worthington-Simpson single and two-stage horizontal split-casing centrifugal pumps are available in capacities from 15 to 15,000 G.P.M., heads up to 550 feet depending upon capacity. Suction and discharge nozzles are integral with the lower half of the pump, and the upper half can be removed without disturbing shaft alignment or connections. These pumps will operate in series with any type of drive and are particularly suitable for applications where high efficiency and low maintenance costs are required.

Worthington - Simpson Ltd NEWARK NOTTS

P686

Tick **No. 52** on reply card for further details



have you a problem too?

The know-how needed to produce drop forgings to your requirements is dependent on experience backed by modern Technical resources.

If your needs are drop forgings* in special alloy, heat and creep-resisting steels or in special non-ferrous alloys, you'll solve many problems by consulting . . .

*** Drop Forgings are Stronger and Tougher**

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

Tick No. 53 on reply card for further details

POLLARD

SOLID & FLEXIBLE ROLLER BEARINGS

Full range of Solid and Flexible Roller Bearings available from 10 mm. to 350 mm. shaft diameter. Ask for catalogue *RFX*

High capacity Max-Load Roller Bearings in a very wide range also available. Ask for catalogue *MAX*

All interchangeable with and equivalent to bearings of American type and manufacture.

POLLARD BEARINGS LIMITED

FERRYBRIDGE, KNOTTINGLEY, YORKS. Tel: Knottingley 2323

London Office: 44 Hertford Street, London, W.1. Tel: Legation 3888 Telex: 23549

POLLARD BEARINGS (Northampton) LTD., Countess Rd., Northampton. Tel: 3766 Telex: 31-624

CANADIAN POLLARD BEARINGS LTD., Box 424, Oakville, Ontario. VI.5-1667

Tick **No. 54** on reply card for further details

Sealed Couplings by REMOTE CONTROL

This unique form of coupling has been applied to the Control Rod Standpipes of Nuclear Power Stations under construction by GEC/Simon Carves at Hunterston, and AEI/John Thompson at Berkeley, and can be applied to most forms of pressure vessels, pipes and ancillary equipment.

The above information has been published with the kind permission of GEC/Simon Carves and AEI/John Thompson Nuclear Energy Groups.

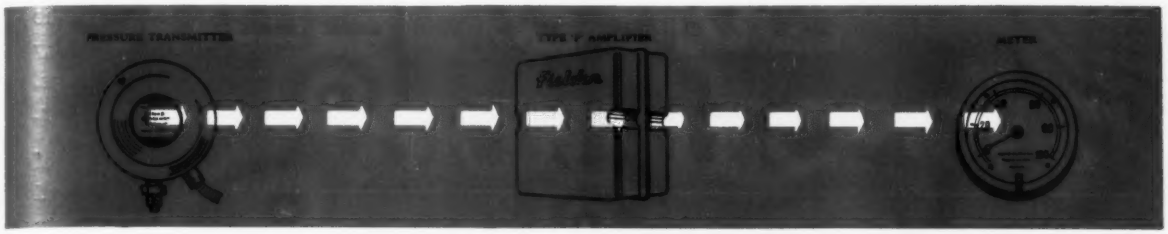
GEARTIGHT UNIONS LTD.

94 South Street, Ponders End, Enfield, Middlesex

Telephone: HOWARD 1881/4. · *Telegrams: Geartight, Phone, Enfield*

Fielden AUTOMATION

Remote Pressure Transmission

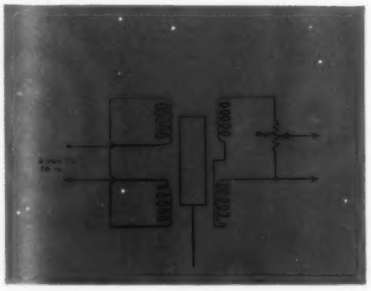


The Fielden system of Remote Indication of Pressure has all the advantages of electrical transmission and yet is so very simple.

The range of equipment covers transmitters for Gauge Pressure, Vacuum, Absolute Pressure and Differential Pressure but in each case the indicating equipment is precisely the same — an important fact from the point of view of spares and maintenance.

Principle of operation

In each Fielden Pressure Transmitter there is a small differential transformer and the output of the transformer depends upon the positioning of a ferroxcube core. This core is positioned by a bourdon tube, diaphragm or bellows depending upon the range. In order to simplify the equipment the differential transformer has been designed to operate on 50 cycles but the voltage is very low and the transformers can be handled, in operation, with perfect safety.



Type 'F' Amplifier

The Type 'F' Amplifier itself is a simple stable amplifier which accepts the signal from the Differential Transformer and amplifies it to the stage when it can be used for direct indication on a moving coil meter.

The Type 'F' Amplifier can be located close to the Transmitter or the indicating meter, whichever is the more convenient, and requires little or no maintenance.

Indicating Meters

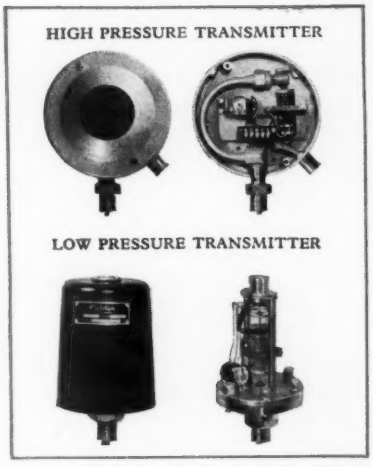
Indicating Meters with 300 degrees scale, 6″ diameter are available as standard, but other patterns and sizes to match other instruments are available.

Schemes available

This Fielden pressure transmission system can be used for single point applications where one pressure is continuously indicated on one meter or a number of transmitters can be switched to one indicator

Transmitters

The High Pressure and Low Pressure Transmitters are illustrated below. These are supplied with standard B.S.P. threads and are screwed into the point of measurement. Simple electrical connections are used to transmit the information to the Indicator.



Ranges

The minimum range of pressure for this equipment is 0-5″ w.g. and the maximum standard range is 0-15,000 p.s.i. although higher ranges can be covered to special order.

Fielden

If you are interested in Remote indication of PRESSURE, VACUUM or FLOW, please write for further information to :—

FIELDEN ELECTRONICS LTD · WYTHENSHAWE · MANCHESTER · Phone: Wythenshawe 3251 (5 lines) Grams: Humidity Manchester
ALSO AUSTRALIA ITALY & U.S.A. *Branch Offices* LONDON · BIRMINGHAM · STOCKTON-ON-TEES · CARDIFF · EDINBURGH

ALUMINIUM ALLOYS

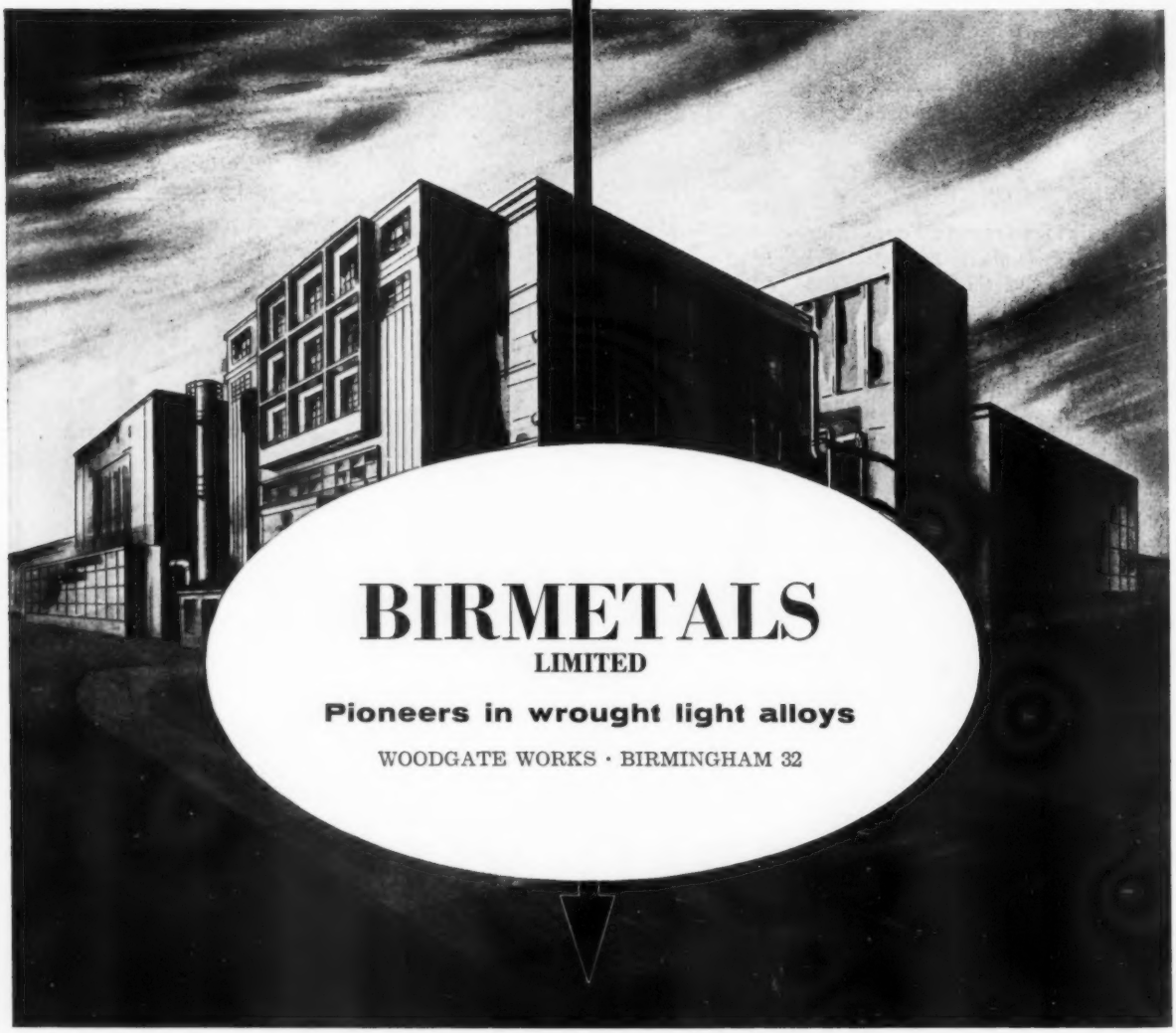
and

MAGNESIUM ALLOYS

for **NUCLEAR POWER PLANTS**

THE RIGOROUS STANDARDS demanded in the field of nuclear engineering are fully met by Birmetals aluminium and magnesium alloys, including special alloys for fuel element cans.

Our long experience in the production of wrought light alloys has been usefully placed at the service of the United Kingdom Atomic Energy Authority, and is offered with equal confidence to commercial constructors now entering the nuclear engineering industry.



BIRMETALS

LIMITED

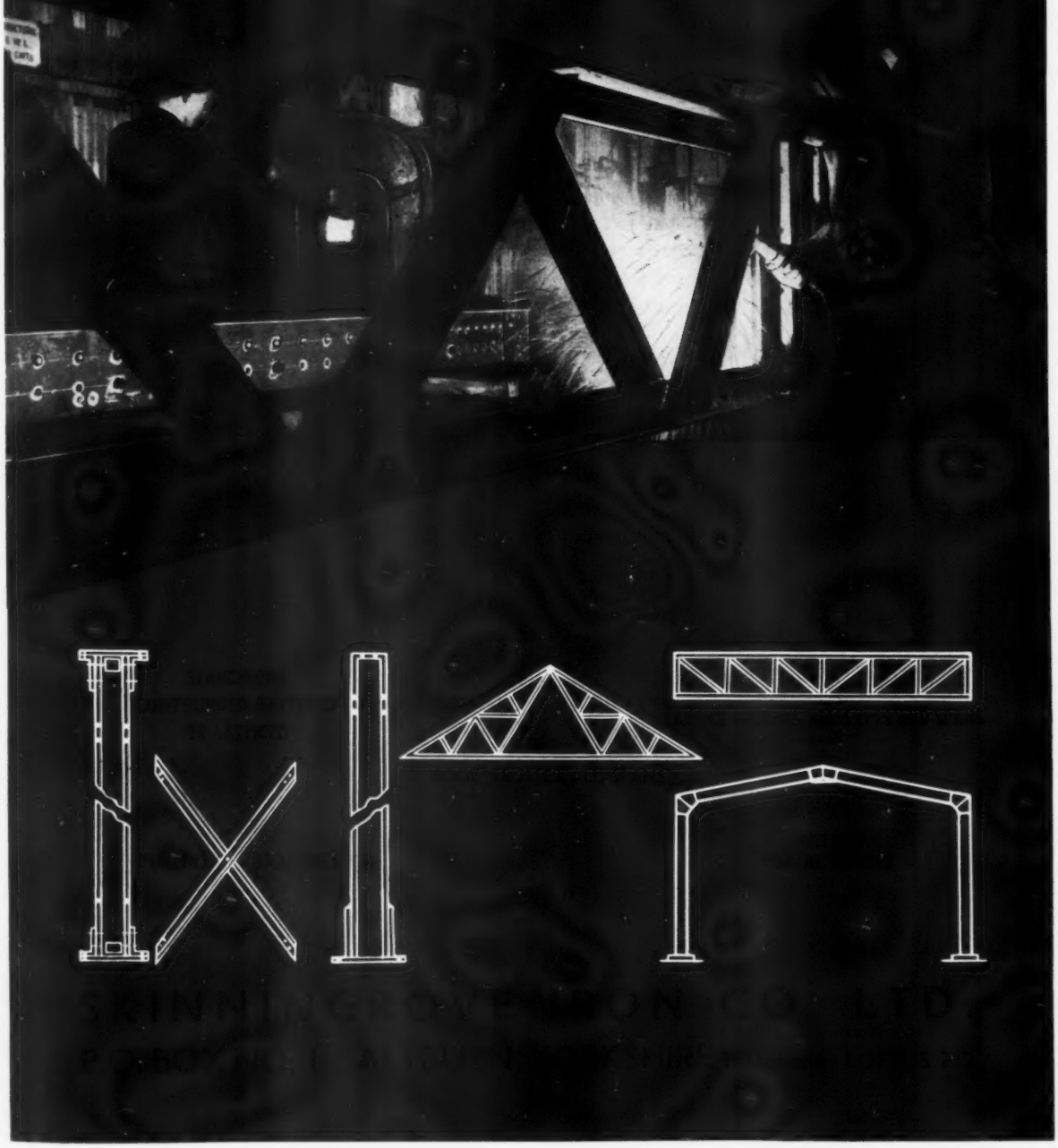
Pioneers in wrought light alloys

WOODGATE WORKS · BIRMINGHAM 32

BM103

RIVETED WELDED STEELWORK

SKINNINGROVE



Tick **No. 58** on reply card for further details

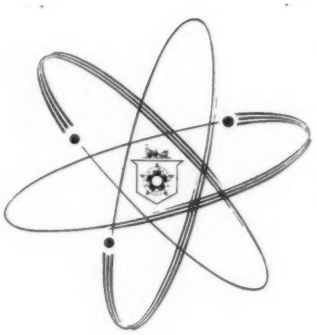
NUCLEAR ENGINEERING cannot tolerate faulty design or ill-chosen materials. Every inch of a plant that houses such enormous energy has to be designed and constructed to highly critical specifications. That is why such contracts go only to the cream of industry.

For this reason we at the Darlington Insulation Company are particularly proud to list, among our many major achievements, the honour of being the first insulation contractors to work on a British nuclear power station.

The Calder Hall project involved a succession of new problems during construction, the testing nature of which was just another challenge successfully met by the skill of our engineers.

Your insulation problems (whether heat, cold or sound) call for the same wide experience, the same awareness of new developments in engineering, as well as suitable materials of proven efficiency.

A talk with one of our technical representatives will cost you no more than a letter or a 'phone call. The Darlington Group of Companies are always at your service and would be pleased to help you right away. Ring Newcastle 23666 and tell us your problem now.

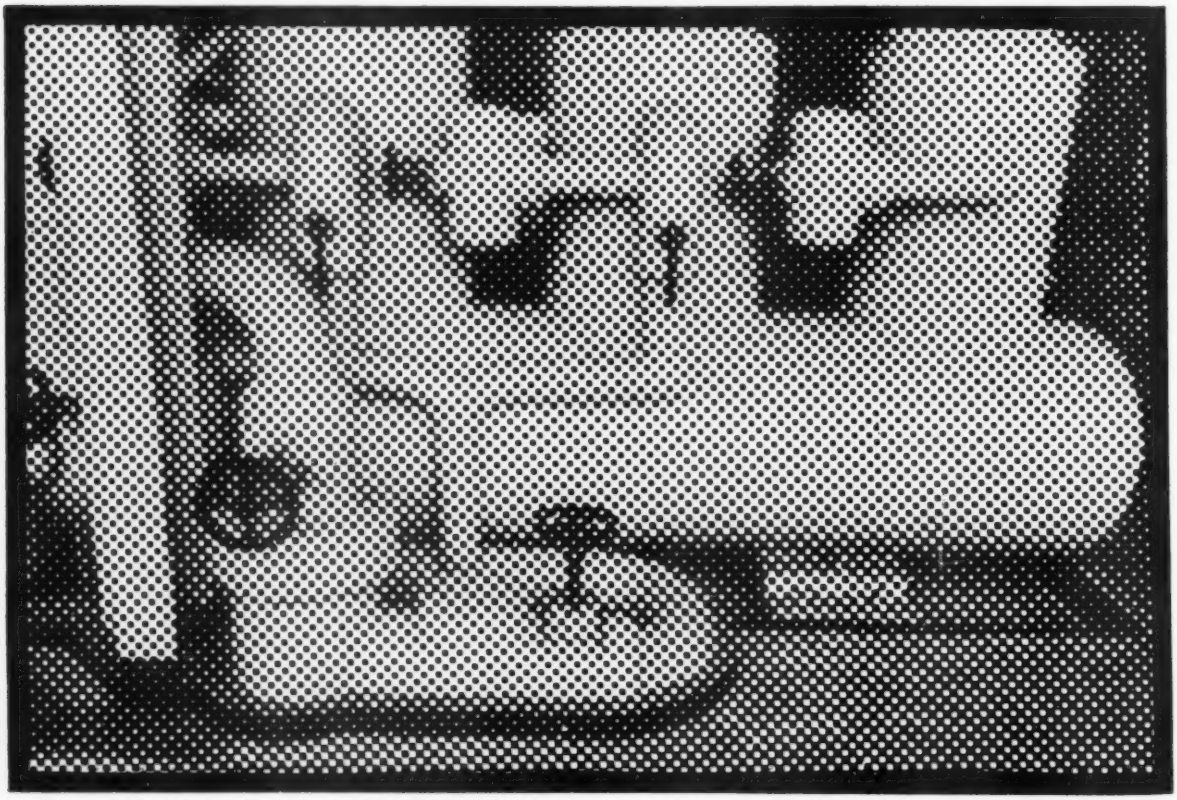


THE DARLINGTON INSULATION CO. LTD

Head Office: 38 Great North Road, Newcastle upon Tyne

Branch Offices at: London, Birmingham, Bolton, Bristol, Cardiff, Glasgow, Leicester, Sheffield

H9



Publishers Column

*Z*enith *E*ffort *T*hursday *A*fternoon

That is exactly what ZETA came to mean to us.

Now a publisher of monthly, or for that matter weekly, periodicals, has always a secret envy for the daily newspaper. So great is its production capacity, so large its staff, that it can report (often very accurately too!) and print in hours, where we may take days or sometimes weeks.

But we had our chance on Saturday, January 25th to dispel this gnawing envy; and we succeeded.

The AEA told us on Monday 20th that they would release to the world the details of ZETA on Friday the 24th.

But—and this was the big but in our lives—NUCLEAR POWER was to be published on the day before the release; on Thursday 23rd.

So we took the major decision of delaying publication till the following Saturday.

Britain opened her newspapers on that Saturday morning to read of Harwell's great success.

That same morning they also read it in NUCLEAR POWER.

We were in fact the first engineering magazine in the world to publish this now famous story. Our managing director went early that Saturday morning to the printers to congratulate the works manager and machine minders on their wonderful job. But all he got from them apparently was b . . . Zeta, no b . . . sleep and nothing to eat all night!

So we respectfully request the Atomic Energy Authority to consult us on our publication dates before they ever do a thing like this again. If not we had better make our reservations at the London Clinic now.

Nuclear Power

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

MARCH 1958 **VOLUME 3** **NUMBER 23**

MANAGING DIRECTOR.....A. H. David Rowse MA (Cantab)
EDITOR.....William Davidson MSc (Eng) DIC
ASSISTANT EDITORS.....Patricia May BSc
John Woodeson BSc (Eng)
EDITORIAL ASSISTANTS.....Ralph Brock
Angela Funnell
PRODUCTION MANAGER.....The Hon Gerald Vane BA (Cantab)
CIRCULATION.....F. M. Rice

CONSULTANT EDITORS
INSTRUMENTATION.....Denis Taylor PhD, MIEE, FInstP, Northampton
PHYSICS.....James F. Hill BSc, Harwell
METALLURGY.....Prof J. G. Ball BSc, FIM, London University
ISOTOPES.....A. G. Maddock MA, PhD, DIC, Cambridge University

ADVERTISEMENT DIRECTOR.....Harry T. Kane
ADVERTISEMENT MANAGER.....John Abram
BIRMINGHAM OFFICE.....Trevor N. Bertram
MANCHESTER OFFICE.....John K. Graham
NEWCASTLE OFFICE.....Peter Doig
NEW YORK OFFICE.....Walter J. Masterson Jr

IN THIS ISSUE

SPECIAL FEATURES

ZETA thermonuclear apparatus 106
More pictures

Dismantling hot loops 108
New Harwell facility

Safe working with beryllium 112
R. O. R. Brooks, Harwell

Uranium mining and processing in France 125
Maurice Moyal, PhD

NUCLEAR POWER ENGINEERING

Electrical process control 98
J. C. Nutter, MA, AMIEE

Manufacture of APPR fuel elements 110
American production process

NUCLEONIC INSTRUMENTATION

Demonstration radiation monitor 129
W. Kiryluk

PROGRESS IN INDUSTRY

Fission product precipitators 119
Dowty Nucleonics Ltd

SCEPTRE TN machine and MERLIN reactor 121
AEI Research Laboratories

Reactor simulator 123
English Electric Co Ltd

REGULAR FEATURES

Publisher's Column A59
Letters to NUCLEAR POWER A61, A63
Leader A65
Worldview 93
Equipment 115
Cross Section *Gracchus* 128
Books 131
Companies 132
Institutions 135
Names in the News 138
Catalogues & Bulletins 138
Research Reports 140
March Diary 140
Patents 142

ROWSE MUIR PUBLICATIONS LIMITED
3 PERCY STREET, LONDON, W1. MUSEUM 8252

Tick No. 59 on reply card for further details

research continues

Shell's leadership in lubrication is based on continuous progressive research, the kind carried on at their Research Centre at Thornton-le-Moors, Cheshire since 1941, by a staff which today numbers nearly 900.

Engineers, metallurgists, chemists, physicists and statisticians are employed directly on research projects, pre-eminent among which are lubricating oils for engines and industry generally.

It was at Thornton that Shell, using their own cobalt sources of irradiation, developed their range of Atomic Power Lubricants* for Calder Hall.

The new C.E.A. Nuclear Energy Power Station at Bradwell is furthering the practical experience gained at Calder Hall. Meantime, at Thornton, research continues.

SHELL

The Shell A.P.L. range is further proof of Leadership in Lubrication.

SIR! LETTERS TO NUCLEAR POWER

FBI Conference

SIR: I have seen somewhere that there is to be a big conference in England shortly on atomic energy from an industrial point of view. Can you tell me more about it?

Liège, Belgium P. VERRIEST

▶ *This is probably the conference to be held by the Federation of British Industries at Eastbourne on April 9 and 10. Full details appear elsewhere in this issue.* *Ed.*

Who started it?

SIR: Through reading NUCLEAR POWER I am now well aware that a 'mill' is one-tenth of a United States cent (see e.g. *Worldview* Feb p47) but I would like to know its origin. Is it a contraction?

London, WC2 P. F. CARTWRIGHT

▶ *It is a contraction for 'millibuck' (a thousandth of a dollar). The term 'megabuck' (a million dollars) is also used. Who first used 'mill' we don't know but it was certainly in current use at the 1955 Geneva Conference.* *Ed.*

False colours

SIR: Can you help me about ZETA? I can't understand why these 'false neutrons' produced are no good as far as power is concerned.

Brigton B. L. RIDGEWAY

▶ *We'll try. These neutrons are produced in fusion reactions just like the true thermonuclear ones—from the fusion of two deuterons and of course the energy from each collison is released just the same. However, the false ones arise from a very fast deuteron accelerated electrically colliding with a stationary or almost stationary one. The chances of this happening are very small indeed and one could never hope for a useful return of energy. Furthermore even if you do get a collision it does not necessarily lead to a fusion and in an unsuccessful encounter the energy of the fast deuteron is shared with the slow one and then neither will be fast enough to cause fusion in their next collision. Thus most of the deuterons accelerated at great expense would do no good at all as far as power is concerned. In a very hot gas, however, all the deuterons are going at roughly the same speed—they are equally 'hot'—and in an unsuccessful collision there is little if any loss of energy leaving them still in the running for another attempt.*

The energy of the electrically accelerated neutrons, wherever they come from, depends on the voltage. whereas the temperature of the gas depends largely on the current. If the current of ZETA can be increased without stepping up the voltage an increase in the number of neutrons observed should indicate that they are of true thermonuclear origin. *Ed.*

Confusion

SIR, In the Jan 1958 issue, in the Sir Christopher Hinton and R. V. Moore paper, the curves on pages 12 and 13 show ratings per tonne. What is the difference between tonne and ton? Is tonne a new unit being used in British and Continental technical literature?

Sun Shipbuilding & Dry Dock Co Chester, Penna. G. McCONECHY

international exhibition

I E A

INSTRUMENTS
ELECTRONICS
AUTOMATION

16 - 25 APRIL 1958 OLYMPIA LONDON
admission 2/6

You will be welcome at the 1958 Instruments, Electronics and Automation Exhibition.

MORE THAN 250 BRITISH MANUFACTURERS will be showing the latest and most comprehensive range of exhibits.

OVER 100 OVERSEAS EXHIBITORS will be displaying their achievements in the rapidly developing fields of instruments, electronics and automation. Note the date NOW.

I.E.A.—the exhibition no progressive industrialist can afford to miss.

A Conference will be held throughout the period of the I.E.A. Exhibition. Further information regarding both conference and exhibition will be gladly supplied by the organisers:

INDUSTRIAL EXHIBITIONS LIMITED,
9 ARGYLL STREET, LONDON, W.1. Tel: Gerrard 1622

A61

BURST FUEL ELEMENT DETECTION EQUIPMENT

WE ARE SUPPLYING complete sets of gas sampling valves, precipitators and associated equipment for some of the reactors now under construction. We are designing and testing fission product detection systems for gas and water-cooled reactors. This specialisation is resulting in greatly simplified and lower cost equipment.

DOWTY *Nucleonics* LTD.

BROCKHAMPTON PARK · ANDOVERSFORD · GLOS.

Member of the DOWTY Group

SIR!

▶ *This is certainly rather confusing—a tonne is a metric unit and equals 1000 kilograms. For most practical purposes it can be regarded as equal to the ton—to be exact 1 tonne = 0·9842 ton. Further confusion arises from the use of the American short ton which is 2000 lb. For this reason the British ton of 2240lb is sometimes referred to as a 'long' ton.* *Ed.*

Let's think again

SIR: While generally agreeing with your reply to Mr. MacDonald (Ships—let's wait *Sir!* Feb 1958) I must support him in his plea for caution. Let me put it this way—I don't think we should wait much longer before starting a ship project but I should like to see some more powerful arguments than those put forward by Hinton and Moore for the graphite moderated reactor as a propulsion unit. Admittedly it is the reactor we know most about and no doubt it could be adapted to a ship with relatively little trouble, but what a ship! Vessels of 100,000 tons are indeed being built at this moment but port and graving dock facilities for these are virtually non-existent in this country. Even a vessel of 50,000 tons seems to me too big for a first nuclear propulsion effort.

By all means let us stick to gas cooling in order to get decent steam conditions but I think we should go for heavy water moderation. A vessel of this type has been planned in Sweden.

Cardiff A. R. SCHWARTZ

▶ *We understand the Swedish project is for a very large land-based power reactor of about 130eMW output. The elements are in the form of pressure tubes and the heavy water moderator tank, which is unpressurized, is of relatively thin aluminium.* *Ed.*

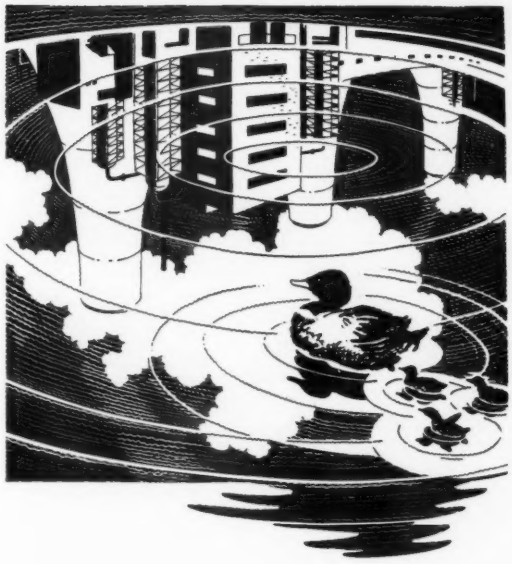
Any takers?

SIR: In the leading article 'Men Wanted' in your February issue you touch on the question of handing over fuel reprocessing to private industry. This certainly might be attractive from the taxpayers' point of view but do you honestly think industry would find it interesting? Perhaps you are not aware that about a year ago the United States Atomic Energy Commission invited proposals from industry for fuel reprocessing plants and the response was so poor that the whole project has been shelved. Now the companies that would be capable of taking on this job will want to know a lot more about costs before they begin to feel serious about this.

Birmingham, 3 T. P. CONNELL

▶ *We thought it was made pretty clear that we had no hope of handing over fuel reprocessing to industry in the immediate foreseeable future. There are many aspects to this, the economics of which is only one. For example there is the military angle although this could presumably be got over since conventional explosives are no longer a government monopoly. There is also public safety—not that we think a private plant would be any greater hazard than a state one. But the argument has been put forward that theoretically, at least, a company can go out of business whereas presumably a government cannot. If this did happen it might be difficult to assign responsibility for active material such as longlived fission products in stock.* *Ed.*

Tick **No. 62** on reply card for further details



the source of power changes

...but water is still of great importance

No risks can be taken with the storage of water in modern plants. Tanks must have complete and lasting internal protection.

They should, in fact, be treated with BITOTES Solution and Enamel. Bitotes prevents interior corrosion of water tanks, pipelines, cisterns, reservoirs, and all water containers, cannot crack or peel and is odourless and tasteless when dry. Fully approved for Fresh Water, Drinking Water and Demineralised Water Tanks, etc.

We will be glad to supply you with full details.

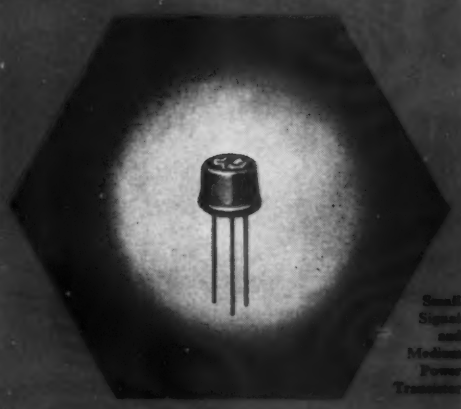
BITULAC LIMITED

(PAINTS DIVISION)

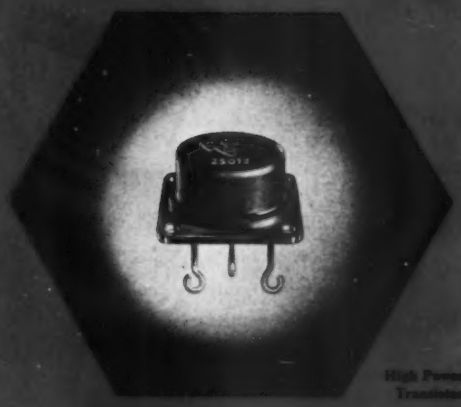
Collingwood Buildings, Newcastle upon Tyne, 1.
Telephone: Newcastle 2-5401

London Office: 219/220 Dashwood House, Old Broad Street, London, E.C.2.

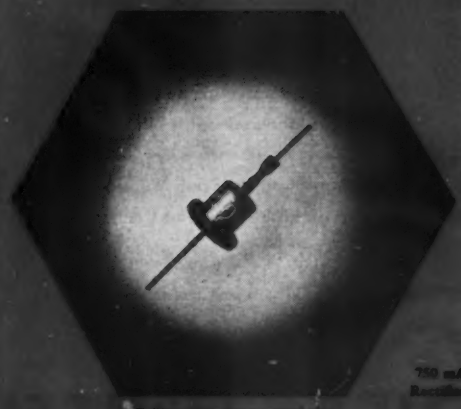
HERE and NOW TEXAS HAVE THE RANGE...



Small Signal and Medium Power Transistor



High Power Transistor



750 mA Rectifier

Illustrations are actual size

Silicon Transistors

Small Signal

This range of general purpose transistors is used for high gain, low level applications. Special features are:—negligible leakage current, a minimum alpha cut-off frequency up to 20 Mc/s, and a tetrode series providing 16 db gain at 30 Mc/s.

Medium Power

These 4-watt diffused base silicon transistors are ideally suitable for output stages in servo amplifiers. A pair in push-pull operation provide sufficient power to drive many types of servo motors. Two types are available, one with a maximum collector voltage of 60, the other of 100; the former is particularly useful for operating from 28-volt battery supplies.

High Power

Texas high-power transistors permit remarkable miniaturisation of power equipment. A collector dissipation of 37½ watts with complete reliability, in such a small device can only be achieved by using silicon. Furthermore, these transistors have a typical alpha cut-off frequency of 5 Mc/s.

Silicon Rectifiers

Medium Power

The new Texas diffused silicon technique has brought a fundamental change in semiconductor rectifiers. Peak inverse voltages up to 600 are featured in each of two ranges now readily available:—a metal-case rectifier provides a mean rectified current of 750 mA, and a glass-seal type provides 400 mA together with a forward to reverse current ratio of $2 \times 10^6 : 1$.

Heavy Duty

Rectifier stack assemblies are available for single phase and polyphase applications in half wave, full wave and bridge configurations. We can supply your requirements for heavy duty rectifiers whether for a D.C. output current of 18 amps or for an R.M.S. input voltage of 3,360 volts.

Complete data sheets are available on request.

TEXAS INSTRUMENTS LIMITED

DALLAS ROAD · BEDFORD · TEL: BEDFORD 68051 · CABLES TEXINLIM BEDFORD

T.7

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING
MARCH 1958 VOLUME 3 NUMBER 23

Specified Perils

The Government's proposals for insurance cover of reactors against third party claims arising out of radioactive contamination following an ccident seem—apart from the actual ceiling of £5 millions—to be generally in line with the ecommendations put forward last June by the British Insurance Association, although until he Bill is published it is impossible to judge how closely.

It is important however to realize that the proposals are only a part of a much bigger picture since they are solely and wholly connected with third party aspects and do not include damage to the reactor and consequential loss to the owner. This aspect of course is no concern of the Government's whose responsibility presumably ends when satisfactory compensatory arrangements have been made for the staff and public.

In 1956 the British Insurance (Atomic Energy) Committee appointed an advisory committee with very broad terms of reference and two of their main recommendations were that (a) a Code of Safety Practice be enforced by law, and (b) the onus of responsibility to third parties should rest with the reactor owners and not the constructors, who should be indemnified. The Committee also obtained Counsel's opinion that although an escape of radioactivity did not in itself cause actual physical damage to property there might be 'damage to proprietary interest' and that this could not be covered by the normal form of fire or explosion policy.

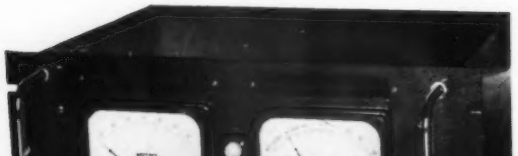
In its proposals the Government seems to have gone further than the BIA in the matter of ensuring safety of operation and propose a ystem of licensing and inspection. Details of this are lacking at the moment but the question that immediately springs to mind is 'who is to do this?' The idea will, however, certainly be welcomed by industry and should play a large part in convincing potential overseas customers that British reactors are perfectly safe.

It might also be wondered why a uniform sum of £5 millions has been laid down as the maximum liability before the accident becomes a national disaster but it is certainly conceivable that a very bad accident in a small research reactor could be worse than a small one in a large power station. In any case, the premiums for this £M5 cover will obviously depend on the size of the reactor, the type and its siting in relation to possible claimants.

As far as the big power stations are concerned, legislation will not need to be on the Statute Book before 1960 but obviously, if the licensing and inspection system is to work the Bill must be pushed through fairly soon to allow time for it to be set up. In only a few months however the AEI research reactor at Aldermaston will be critical and presumably some sort of *ad hoc* arrangement will be required and it will be interesting to see how this is handled.

Regarding the owners' own losses, CEGB conventional power stations are covered by virtually the whole insurance market through the British Insurance Association and no doubt a similar arrangement would apply to the nuclear stations. It is significant however that the BIA in their atomic energy report recommended that over to owners of nuclear reactors should be on an annual basis for specified perils only, including certain new perils, and that cover for loss of profits and consequential loss could be provided only if market capacity had not already been exhausted in respect of cover granted for specified perils and then only through the pools. These however are early days and he insurance men are obviously being ultra-cautious in handling this new risk.

Tick **No 64** on reply card for further details

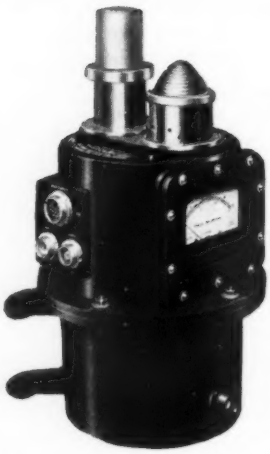


1389 (N588) Reactor Period Meter

1462 (N592) Reactor Power Error Meter

K E E C O

1463 (N593) Ratemeter



1463 (N593B) Fast Neutron Head

Ekco Electronics supplied and installed the complete nuclear instrumentation for reactors at Harwell, Dounrey and Sydney; the complete nuclear intrumentation for the new reactor at Risø, Denmark, will also be supplied by Ekco. In addition to these complete installations Ekco equipment has been incorporated in practically every reactor built to date. Typical instruments from the Ekco range of reactor equipment are illustrated. Please write for further information.

EKCO

ahead in reactor instrumentation

EKCO ELECTRONICS LTD · SOUTHEND-ON-SEA · ESSEX · Telephone: Southend 49491

Progress north of Border

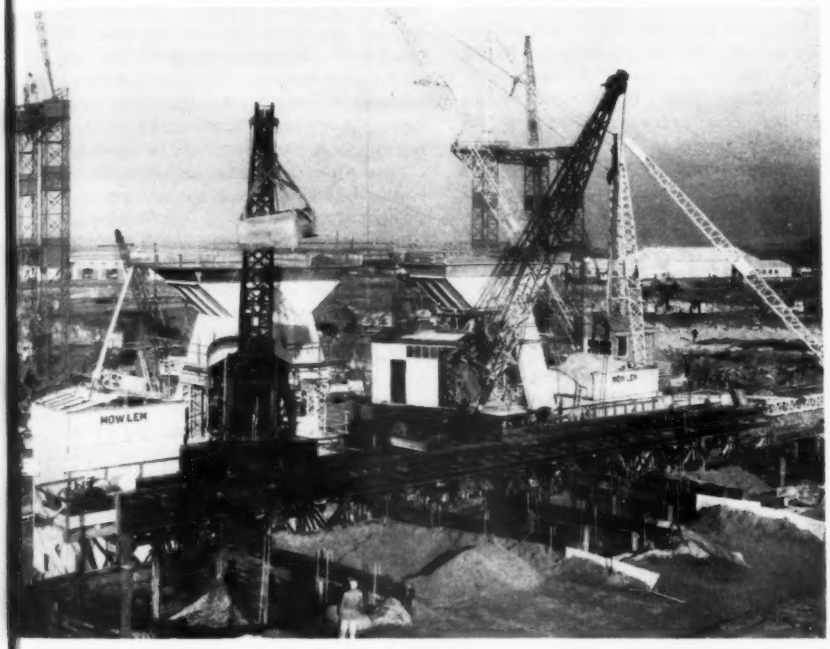
At Hunterston, on the Ayrshire coast, the general layout of Scotland's first nuclear power station is becoming clear. It is being built for the South of Scotland Electricity Board by General Electric in association with Simon-Carves, Motherwell Bridge & Engineering, and Mowlem (Scotland). Temporary works were started at the end of August last year, but permission to begin permanent work was not granted until the middle of October. Up till now work has concentrated largely on the foundations of the first reactor and the turbine hall.

Having removed, on average, eight feet of surface soil and green rock at the reactor base, blasting and excavation began on the foundations to cut out any faults and to produce a level surface prior to the pouring of 3,000 cubic yards of concrete. Work has now started on the reinforced concrete raft above and this will incorporate 8,000 cubic yards of concrete with 400 tons of reinforcing steel. Two of the four derricks required for erecting the main concrete structure are now almost complete.

The turbine-hall excavation, covering about 675 ft by 130 ft and going to 13 ft, is now practically finished, and work has started on the cooling-water inlet culverts. To eliminate the need for blasting in the vicinity of the first reactor once the structural concrete has been placed, the excavations for the irradiated-fuel storage pond have also been completed.

To ensure that civil engineering continues unhindered by work on the main steel structures, a complete workshop and prefabrication apron are being constructed. The workshop—now approaching completion—is a twin-bay, steel-framed building served by two 40-ton travelling cranes. It is designed so that four 80 ft by 20 ft dia. boilers can be assembled simultaneously. The apron in front of the workshop will be used for the prefabrication of the six tiers of each 70 ft-dia. spherical reactor pressure vessel before lifting them into their final position.

The workshop and apron are located on the centre-line of the two reactors so that the Goliath crane, which will be used for raising and placing the boilers and pressure-vessel sections, will pass over these construction areas. This crane, which will be the outstanding piece of constructional equipment on the site, will have a height and span of 200 ft, so that it can straddle a completed reactor building, and will be capable of lifts up to 350 tons. The massive prefabricated sections of the crane legs are already being assembled on site and the bogies on which they will be mounted are in position on their tracks ready for erection to begin.



On the Firth of Clyde, preliminary work is now virtually complete. Seen in the foreground is the central concrete weighbatching plant. Behind this the twin derricks mark the site of reactor A

Licences will be needed

All reactors are to be licensed and inspected and third party cover up to £M5 is to be a requirement of operation under new legislation now proposed by the Government. Some details of the proposals were outlined in the House of Commons on February 10 when Sir Ian Horobin, Parliamentary Secretary, Ministry of Power, in a written reply stated: 'The Government intend to introduce legislation to ensure by a system of licensing and inspection, that nuclear reactors on land are made effectively subject to control in the interest of public safety. All owners of such reactors will be subject to the same duty as the Atomic Energy Authority of preventing damage to property or personal injury from radioactive contamination. They will, therefore, be liable to pay compensation for such damage even if it is due to an unavoidable accident, except of course to the extent that the claimant injured has been guilty of contributory negligence. In order to make this provision effective a reactor owner will be required to insure his liability or to show that he is holding adequate liquid assets. In these circumstances, the Government have decided that it would be right to put some limit on the amount of compensation which reactor owners might have to pay in respect of any one incident. They propose, therefore, to include in the legislation a provision fixing this limit at £5 million in respect of each installation, a figure which they are advised is much more than adequate to cover any reasonably foreseeable risk. The insurance market have informed the Government that they are ready to provide the necessary cover. The liability of the Atomic Energy Authority will be unaffected. Problems of reactors in ships, submarines and aircraft require further study having regard particularly to the international aspects.'

Government responsibility Later a spokesman of the Ministry of Power pointed out that the figure of £5 million was a purely arbitrary one—an outside figure. The Government did not believe there was any real danger of damage up to anything like this figure, but it was necessary to make provision against even the unlikely eventuality. The damage in the Windscale mishap, for example, was unlikely to have exceeded £60,000 to £70,000 for milk and a relatively small amount for other claims.

If an incident caused greater damage than £M5 the reactor owner would not be liable for the excess: it would be the sort of major national disaster that the proposed system of licensing and inspec-

tion is designed to render impossible and in which it is customary for the Government to alleviate cases of hardship.

Questions about premiums will be, in the first instance, a matter for the insurance market and the reactor owners who have plenty of practical experience in dealing with each other on insurance matters.

The present proposals were concerned with fission reactors; as far as we know, said the Ministry official, there is no contamination risk from the fusion process. They relate only to damage resulting from radioactive contamination since the liability of a reactor owner for damages due to other causes, and the rights of injured parties to claim against him will not be affected by the proposed legislation. Preparatory work on the proposed Bill was going ahead as rapidly as possible, but it would not be ready during the current session of Parliament.

The Atomic Energy Authority under Section 5(3) of the Atomic Energy Authority Act, 1954, have the duty to secure that no ionizing radiations from their premises cause harm to persons or property. This makes the Authority liable to pay full compensation, without limit, for any such harm they may cause, except to the extent that the injured party has been guilty of contributory negligence. The Authority, like Government Departments, do not insure.

An Editorial comment on the proposals appears on page A65.

in addition to his position as managing director of the Industrial Group—the design and construction of Calder Hall was one of his responsibilities—and his departure from the Authority threw a strain on the other members.

The undesirability of overburdening those at the top was one of the points emphasized by the report of the Fleck Committee after the Windscale accident. In the past, three full-time members of the Authority have each been responsible for formulating policy in their own special field, and considering general policies to be followed by the Authority as well as running an establishment.

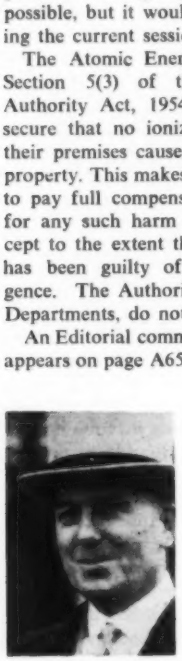
The purpose of the alterations which are being made, says the Authority, is to 'free these members from their executive duties, and thus enable them to devote more time to their other responsibilities.' Sir William Penney is now the only one of the three executive leaders of the Authority's groups to be left with a double responsibility. He will continue as member for weapons research and as director of AWRE pending a new appointment for the latter post. Sir William Cook, the new full-time member, was scientific director of last year's hydrogen bomb tests at Christmas Island. He was knighted in the New Year Honours.

Harwell changes Dr Schonland is the first director of Harwell who is not also a full-time member of the Authority. During the latter part of the war he was deputy managing director. Mr Stewart, who is 41, was formerly director of technical policy. He moved to the group in 1949 from Harwell, where he worked on the first atomic reactor to be built in the UK. The new appointment will free Sir Leonard from many routine duties and give him more time for making contact with outside bodies.

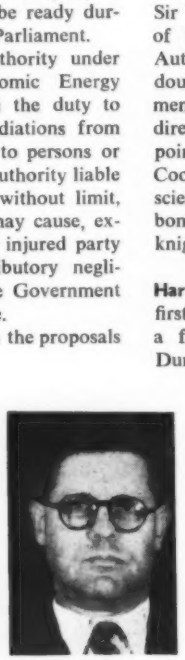
Dounreay now has its own director—Dr R. Hurst, who was previously chief chemist in the research and development branch. Dr Hurst wrote in last May's issue of NUCLEAR POWER on a design study for a homogeneous aqueous reactor.

In its report the Fleck Committee emphasized the great importance of recruitment, training and promotion of personnel and recommended that the post of director of administration should be upgraded and renamed director of personnel and administration. This has been done and Mr D. S. Mitchell, 39, is now responsible for personnel policy throughout the whole Authority, including interchange of staff between the groups.

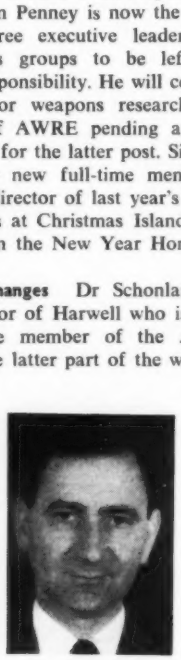
Other appointments in the Industrial Group announced by the AEA include that of Mr. J. B. W. Cunningham who leaves his job as deputy director (civil reactors) to become director of industrial power. He has been at Risley since 1947. New director of research and development will be Dr H. Kronberger, OBE, replacing Mr L. Rotherham, whose appointment as a member of the CEGB was recently announced. Dr Kronberger is 37



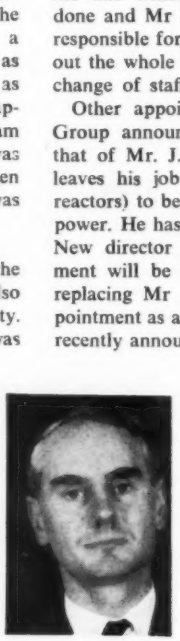
COOK
member for engineering & production



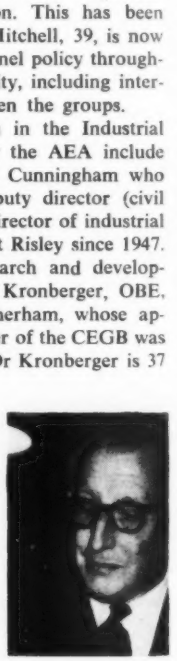
HURST
director of Dounreay



CUNNINGHAM
director of industrial power



MITCHELL
director of personnel



SCHONLAND
director of Harwell

Fleck changes ease the load

The changes in the higher organization of the AEA—designed to lighten the load on members of the Authority—have begun recently. Sir John Cockcroft, who is 60, retains his position as AEA's member for scientific research, but has been succeeded as director of Harwell by Dr B. F. J. Schonland who has been deputy director for 3½ years. Sir William Cook, until recently deputy director of AWRE, Aldermaston, has become a full-time member of the Authority responsible at board level for policy questions on production and engineering. This job was formerly held by Sir Christopher Hinton, scientific adviser to Field-Marshal Montgomery. His position as deputy director is now occupied by Mr D. W. Fry who in his capacity as chief physicist was in charge of the staff which worked on ZETA.

New posts in IG Three of the new posts in the Industrial Group which the Fleck Committee recommended have been created—those of deputy managing director, director of Dounreay and director of personnel and administration.

Since last September Sir Leonard Owen has been managing director of the IG—the other job vacated by Sir Christopher Hinton—and he will now be assisted by Mr J. C. C. Stewart in the capacity of and was primarily responsible for the development of diffusion plants for the separation of the uranium isotopes. He was appointed chief physicist at Risley in 1956.

More reactor courses

The two reactor engineering courses in this country run under the AEA have proved so popular that technical colleges are to take over some of the work.

Birmingham, Bradford and Salford will run preliminary courses for the Harwell Reactor School, which has attracted many engineers and physicists, including more than 80 from overseas in the last two

years. Number of courses a year at Harwell was recently increased to four, each lasting sixteen weeks, together with two for senior technical executives lasting nine days. The next standard course will begin on April 14, and the next executive course on May 12.

The Whitehaven College of further education is hoping to set up a course for its students to include some of the ground covered by the Calder Operation School. This was started in January last year to train engineers in the principles of operation of Calder reactors. Six courses have been completed and the next starts on March 10. They have been attended by many engineers from the CEGB and industrial firms both in the UK and overseas. The course itself lasts for six weeks and its aim is to give students an outline of the design, construction and operation of Calder type plants. They are taken through all the stages of the start-up nuclear tests which are carried out before and after the reactor becomes critical for the first time. Whenever possible start-up and shut-down procedures are illustrated by the reactor itself. In other cases a complete simulated control desk is used. This has the same time constants as the reactor itself and wrong operation causes a shut-down by means of trip circuits. At the end of each course talks are given by members of the industrial reactor design groups about their particular designs to stress the differences between a reactor of the Calder type—designed primarily for plutonium production—and one designed to give power. Special courses are run for overseas engineers so that those with little command of English will not feel embarrassed when asking questions.

Bread before beauty

Lively demonstrations took place at the public inquiry held this month at Trawsfynydd, Merionethshire, into the proposal to build a nuclear power station there. Proposed site is in Snowdonia National Park and will cover about 180 acres of rocky land on the north shore of Trawsfynydd Lake. As reported in *Worldview*, September, the station will be 400 to 500MW and be connected by overhead line to the 275 kV transmission system at the Ffestiniog pumped storage station now under construction a few miles to the north. Cooling will require 35 million gallons per hour from the lake which may limit slightly the use of water in dry weather by the Maentwrog hydroelectric scheme, for which the lake was originally constructed thirty years ago.

Principal objectors to the proposal are the North Wales Hydro Electric Protection Committee and the Council for the Preservation of Rural England and Wales. But amongst the Welsh people the proposal received an enthusiastic welcome. Depopulation has been a problem in the area for some years: since the turn of the century, the population of Blaenau Ffestiniog has fallen from 14,000 to 7000 mostly by the loss of young people. Numbers of young men are at present unemployed and the situation will become worse soon when the neighbouring War Department camp closes.

During the five to six year construction period, the station would give employment to 2000 or 3000 people, most of whom would be recruited locally. When completed 300 or 400 will be permanently employed. At the enquiry, bands of unemployed carried banners with slogans such as 'Bread before beauty', 'Pylons before poverty', 'Keep the youth of Wales in Wales' and 'Power lines—not lines of unemployed.'

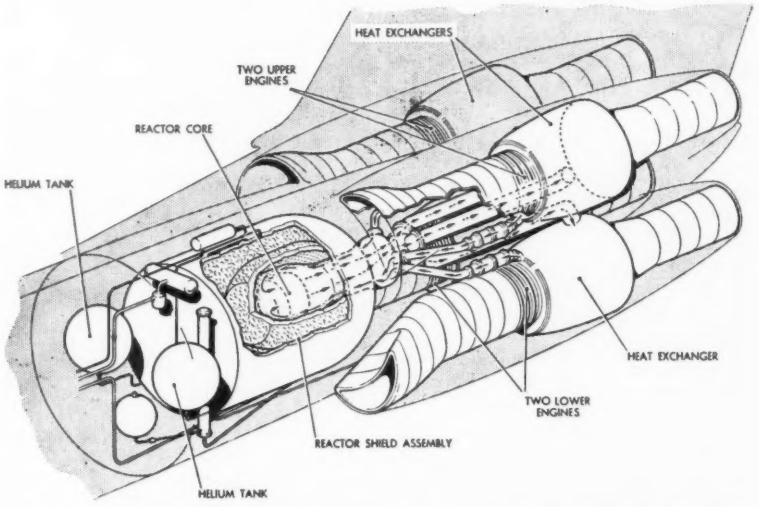
The enquiry is being conducted by H. W. Grimmitt, chief engineering inspector of the Ministry of Power, and C. D. Buchanan, a principal inspector of the Ministry of Housing and Local Government. Their report has to be submitted for consideration by the Ministry of Power.

De Havillands see plane systems

There appears to be no fundamental obstacles to a reactor small enough to power a large subsonic plane, provided some compromise can be arrived at for the shielding problem. This is the view of Prof A. D. Baxter and Mr G. E. Preece of the De Havilland Engine Co put forward in a recent information release on the activities of the company's nuclear energy group. One type of reactor envisaged would be gas- or liquid-metal-cooled and would drive gas turbines in a closed-cycle system. It could be designed to fit into a cylinder only 3 ft by 3 ft and, if operating temperatures of about 750°C could be reached, 30MW heat output could produce the necessary 10,000 hp for a 200,000 lb plane. However, since 100 pct shielding could not be provided on all sides, it would be necessary to take off and land using auxiliary turbo-jets or rockets.

Aircraft propulsion is, however, not the only field the firm are interested in and concepts have been developed for land and sea transport, stationary power stations and even interplanetary flight using the ion rocket.

De Havillands disclose that they have been working on nuclear energy since 1954 and are at present designing, in collaboration with Harwell, a closed-circuit in-pile loop for testing a new type of ceramic fuel element from which very high temperatures could be attained. The firm put at about five years the time required from the conception of a basic idea to the realization of an experimental power reactor of these advanced types.



In this proposed layout by De Havilland of a nuclear power plant for a large transport aircraft, reactor is cooled by helium at 1000 psi. Heat exchangers, at about 1000°C, replace the combustion system of a conventional turbojet

Plant extensions at Springfields

A contract for a fume absorption system to be installed as part of the new extensions to the AEA's Springfields uranium factory has gone to Kellogg International Corporation, London. Designed to recover nitric acid from nitrous fumes arising from the three sections of the main plant, the absorption system will consist of six 6 ft-dia. by 40 ft-high Raschig-ring packed towers and a recirculation pump with heat exchanger for removing the heat of absorption. Most of the plant will be in stainless steel. Construction is scheduled to start very shortly and commissioning will take place in April.

CANADA

More uranium from Canada

Canada will sell over 5000 tons of uranium ore to Britain in 1962-63. Price is $M105 (about £M37) and delivery to the AEA under the new contract will begin in April, 1962, when supplies under the present order come to an end. It is reported that Canada is willing and able to supply a substantial part of the Authority's uranium requirements after 1963, and that negotiations about this are in progress.

CanWest step in

A reactor using natural uranium but competitive with enriched fuel designs is the objective of a new conceptual design recently announced by Canadian Westinghouse. Basis of the heavy-water-moderated-and-cooled design is the system of incremental cross-feeding fuelling first proposed in 1956 by W. B. Lewis of Atomic Energy of Canada Ltd. In this, elements are fed in from opposite ends of adjacent channels so that spent fuel in one channel is adjacent to fresh fuel in a neighbouring channel. With frequent loading this maintains a high reactivity in the core.

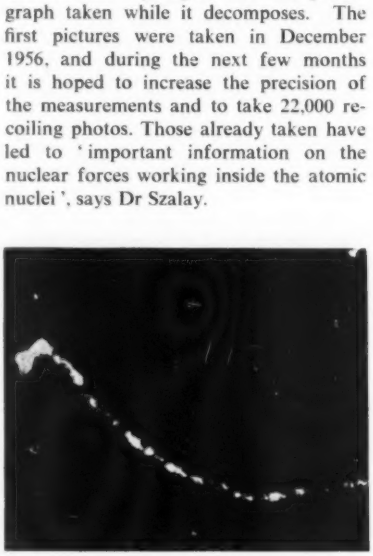
Known as the HPTR (horizontal pressure tube reactor) Westinghouse's new design seems to follow the general style of the redesigned NPD. The fuel elements are clusters of small Zircaloy tubes containing natural uranium oxide and they are contained in the pressure tubes through which flows the coolant heavy water. The moderator heavy water surrounds the pressure tubes and is maintained at quite a low pressure, thus dispensing with an expensive pressure vessel. The initial design does not allow for on-load fuelling but suggests changing 5 pct of the fuel every four weeks.

For a 130eMW plant costs in Canada are estimated at between 8 and 12 mills/kWh excluding development costs. Much of the cost is due to the amount of zirconium used and a reduction in this would make a big difference to HPTR. The 130eMW it is estimated would cost $M50 to build.

HUNGARY

Neutrino recoil photographed

With the aid of extremely high speed photography and a Wilson cloud chamber, a team at the Debrecen Nuclear Research Institute in eastern Hungary has succeeded in photographing the recoil of the neutrino. This is the nuclear particle first postulated by Pauli in 1931 to account for conservation of energy and momentum in beta emission, and only positively detected by the USAEC at Los Alamos in 1956. The method used in the Hungarian work was developed by Dr Sandor Szalay, founder and director of the Institute, who got his nuclear research training at the Cavendish laboratory in 1936. The neutrino source is the isotope helium 6 which has a very short half life—0·7 sec—and decays by beta emission accompanied by a neutrino. After isolation, the helium isotope is blown into the cloud chamber operating with rarified hydrogen, and the photograph taken while it decomposes. The first pictures were taken in December 1956, and during the next few months it is hoped to increase the precision of the measurements and to take 22,000 recoiling photos. Those already taken have led to 'important information on the nuclear forces working inside the atomic nuclei', says Dr Szalay.



Neutrino recoil track was photographed recently at Hungary's Nuclear Research Institute

Nuclear plans under way

The Soviet tank-type research reactor under construction at Liberty Hill, overlooking Budapest will 'almost certainly' be put into operation in the summer, according to Lénard Pál, deputy director of Hungary's central physical research institute. Work began on the reactor—described as 'medium-sized'—in June, 1956, and last September plans were announced to advance completion date by six months. Another research reactor is to be installed at the Nuclear Research Institute at Debrecen, eastern Hungary, bought with the Institute's own funds.

Selection of sites and types of nuclear power stations is also under consideration, says Prof Lajos Janossy, vice-president of the Atomic Energy Committee. Nuclear power development is important in Hungary as coal stocks are not large and consist mainly of poor quality brown coal. However, uranium deposits have been located and mining has now started 'at a rapid pace.' But there are several difficulties in the nuclear programme. Janossy admitted that not enough is being done to educate students in atomic physics, and that although there are courses at Debrecen and Budapest Universities, they have run into 'beginner's difficulties.' Also not enough nuclear instruments are yet being produced in Hungary, although prototypes have been made and shown at international exhibitions.

UNITED STATES

New orbits for AEC?

Proposals that would give the Atomic Energy Commission powers to achieve the development and control of outer space are contained in a Bill introduced in the Senate on Jan 23 by Clinton P. Anderson (Dem NM). With $M50 authorized 'to finance initial operations and construction,' the Bill would amend the Cole-Hickenlooper Atomic Energy Act of 1954.

Senator Anderson—an ex-chairman of the Joint Committee on Atomic Energy and still a member—proposes that the AEC set up a Division of Outer Space Development and also an Outer Space Advisory Committee of seven members appointed by the President. Further, the Bill proposes both a National Laboratory for Outer Space Propulsion to be run by the AEC and an International Laboratory for Outer Space Propulsion to be set up jointly by cooperating nations.

INTERNATIONAL

UN studies radiation hazards

The 'somatic' effects of radiation on people—that is those not passed on to their descendants—was the first topic considered by the UN atomic radiation committee in its fourth session, now being held in New York. Opening the session Mr Dag Hammerskjöld stressed the 'very hard work' confronting the members. Earlier meetings had considered the scope and form of the report—due to be published in July—and the detailed information required, and now came 'the crucial stage of the formulation of the report.' It will cover such matters as the genetic effects of radiation, the contamination resulting from atomic energy installations and the possible hazards in medical uses of radiation as well as extent and effect of fall-out from bomb tests. The report will be written in non-technical language to facilitate as wide an understanding of its contents as possible, and the scientific material received from various countries will form an annexe. So far more than 160 documents from some thirty governments have been received.

At a press conference held soon after the beginning of the session Professor Zenon Bacq of Belgium, the chairman of the committee, emphasized the friendly spirit which had pervaded its discussions.

So far, he said, all decisions had been taken unanimously. Several of the correspondents asked questions about the holding of bomb tests, but the Professor maintained that the issue of whether or not the tests should be ended was outside the scope of a scientific committee. The decision was a political one, he said, and should be made by 'political men.' Dr Shields Warren of the US, chairman of one of the five sub-groups, reminded those present that bomb tests did not constitute the only danger and that the committee was concerned with the danger from radioactivity 'wherever various types of uranium fuels are utilized.'

AEA directors appointed

The Board of Governors of the IAEA, in its recent series of meetings at Vienna, took measures to ensure that member states will be kept up to date on the fissionable materials at the Agency's disposal. In the early stages at any rate the Agency will act as broker rather than stockpiler of materials and will concentrate mainly on ensuring continuous supplies.

The UK and USA indicated that they will make substantial voluntary contributions towards the Agency's £90,000 Fellowship Programme and in addition notifications were given by various members that they would place fellowships and training facilities in their own countries at the Agency's disposal. The Agency will also study the possibility of establishing a regional training centre in Latin America.

Mr Sterling Cole, Director General of the IAEA has announced the appointment of directors to the following divisions:—

Reactors—Mr Josef Snizek (Czechoslovakia); Isotopes—Mr Yoshio Fugioka (Japan); Technical supplies—Prof Mario Eduardo Guido Bancora (Argentine); Scientific and technical information—Mr John Edward Commins (Australia); External liaison—Mr David Fischer (South Africa); Economic and technical assistance—Mr U. L. Goswami (India); Research — Prof Antonio Rostagni (Italy); Exchange and training of scientists and experts—Prof Joaquim da Costa Ribeiro (Brazil); Health, safety and waste disposal—Mr G. W. Campbell Tait (Canada); General services—Mr Donald G. Sullivan, seconded from office of Dr Ralph Bunche, Under-Secretary of UN; Personnel—Mr Karol Kraczkiewicz (Poland).

Representative of the IAEA with the UN will be Mr Andrey Ivanovich Galagan, senior officer to the IAEA secretariat. Dr Henry Seligman was sworn in as Deputy Director General, in charge of departments for research and isotopes (see *Worldview*, February).

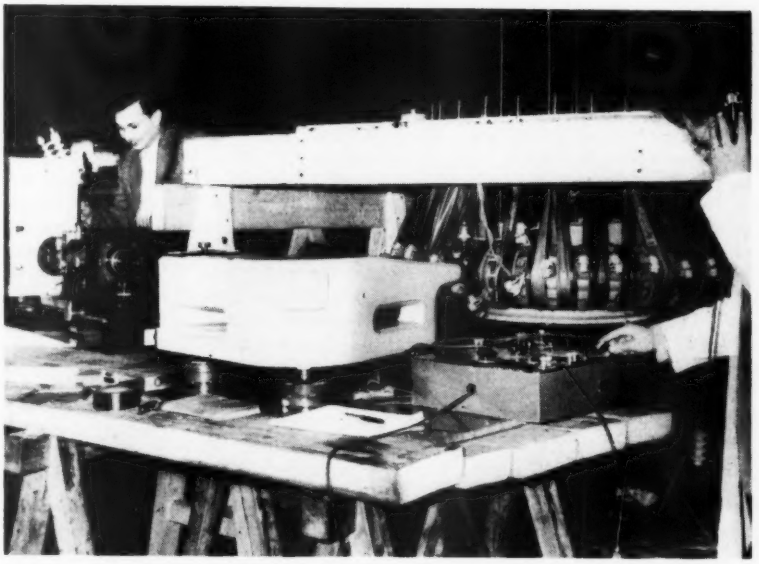
WORLDBRIEFS

Staff of the **Euratom** and Common Market commissions is to be stationed in Brussels for at least two years. Meetings of the commissions themselves will be held alternately in Brussels and Luxemburg.

HRE-2—Oak Ridge's second homogeneous reactor—went into operation early in January. It's a two region reactor using uranyl sulphate in heavy water. Rated output is 5tMW. Some heat can be used to drive 300 kW turbo set.

Further contract—worth over £600,000—for work at **Winfrith Heath** has been awarded to the Turriff Construction Corp, mainly for construction of laboratories and office buildings. Main civil engineering contract of £M1·2 was given to Turriff in November (see *Worldview*, December).

European Nuclear Energy Agency came into being on February 1, with M Pierre Huet as director. Formerly General Counsel of the OEEC, he has been responsible for work leading to the setting up of the new Agency.



Fusion in France

With this 9 ft circumference toroid called 'Equator,' the French Atomic Energy Commissariat announce they have achieved fusion at a million degrees centigrade for periods of five microseconds. Here technicians are making optical observation of the annular discharge

The **Army Package Power Reactor** has now been formally accepted by the AEC and Alco have been named to operate it and provide training for Army personnel until June 30, 1959. To date APPR has run 3000 hours and produced over 8 MkWh.

The Duke of Edinburgh had lunch with Sir Edwin Plowden and the Executive Committee of the UK Atomic Energy Authority at St Giles Court on Feb 12.

Project for **US atomic icebreaker** has been opposed by the Department of Defense. A Bill to authorize one for the US Coast Guard is before the House but Navy's view is that it would divert effort from more urgent jobs at the present time.

US Navy Bureau of Ships has awarded a £M1·5 contract to Westinghouse for a **small submarine reactor.** Combustion Engineering will look after whole propulsion plant and Electric Boat, the vessel.

Brazil is the first nation to receive a cash grant from the US Atoms-for-Peace programme. A cheque for $350,000 was handed over at Sao Paulo on Jan 25 when the 5 MW research reactor was inaugurated.

Effects of earthquakes on power reactors will be studied jointly by Lockheed Missile Systems and Holmes & Narver Inc of Los Angeles. Results will be published by the AEC.

USAEC in fiscal 1957 sold $M2·9 of isotopes and $M4·4 of heavy water. Figures for 1956 were $M2·3 and $M5. UK had $620,000 of heavy water—at $28 a pound.

By March 8, the UKAEA will have closed its present offices and moved into new premises at 11 Charles II St, London, SW1 (tel: Whitehall 6262). Picture of the new building nearing completion appeared on the title page of NUCLEAR POWER, July.

We recently published an article on telemetering for power reactors. Here are more details of a system based on the linear differential transformer

An electrical process control system for nuclear power plant

J. C. NUTTER, MA, AMIEE
Nuclear Division, Elliott Bros (London) Ltd

SERIOUS CONSIDERATION of systems for process control equipment particularly suitable for use in nuclear plant becomes necessary with the advancement of the science to the point where engineering of a complete nuclear power station is being undertaken. It has been the practice in experimental installations to exercise control entirely by manual operations, and though the industrial diffusion and chemical plants have been large and complex the actual physical processes involved are simple and small in variety. Consequently instruments and control equipment which satisfied a particular requirement have been incorporated and there has been no necessity to investigate systems which would have a wide and perhaps universal application in nuclear plant control.

In the nuclear power station, where a fair degree of automatic control is essential, not only is there a wide diversity in the parameters to be measured, but certain parts of the plant must be controlled in accordance with measured signals from several other sections. Instruments

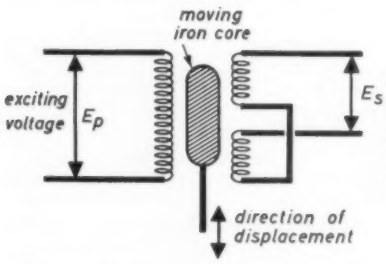


Fig 1 In the linear differential transformer movement of the core upsets the balance in the two secondaries and produces a signal

used for carrying out the measuring and control operations, therefore, must at least employ compatible measuring systems if a large number of transducing elements is to be avoided, and the further advantages in accuracy, ease of maintenance, etc., resulting from the use of a common measuring and transmission technique will be obvious.

A comparison between pneumatic and electrical systems has recently been given (*1*) and it is not proposed to repeat this discussion, except to summarize the advantages of an electrical transmission system. These reside mainly in the improved frequency response, the ease of installation, the facility with which routine maintenance and calibration tests can be made without disturbing the main function, freedom from leakage effects to and from possible contaminated areas, and the minimum requirement for guaranteed ancillary equipment. The following describes the principle of operation of an electrical process control system (Swartout) which has been proved in conventional industrial plant and which, by virtue of the flexibility in its design, is finding ready application to the special problems involved in control of nuclear plant.

Basic system component

The system considered relies upon the properties of the linear differential transformer, shown schematically in Fig 1. This is a device having both primary and secondary windings in a magnetic circuit, part of which consists of a movable core. The secondary winding consists of two similar sections which are symmetrically disposed about the primary and connected together in such a way that the e.m.f's developed are in opposition. Thus with the moving core in its central or balance position, the in-phase component of the net output signal is zero.

If the core is displaced from the balance position, the magnetic symmetry of the transformer is disturbed so that the two secondary e.m.f's no longer exactly balance, and a resultant output signal is produced. The unit is so designed that for small movements the amplitude of the in-phase component of the output signal is linearly proportional to the core displacement, the sense of the signal indicating the direction of displacement from the balance position.

As is customary with balanced transformers, due to stray effects a small residual signal is observed at the balance point whose amplitude is about 1 pct of full output. It is,

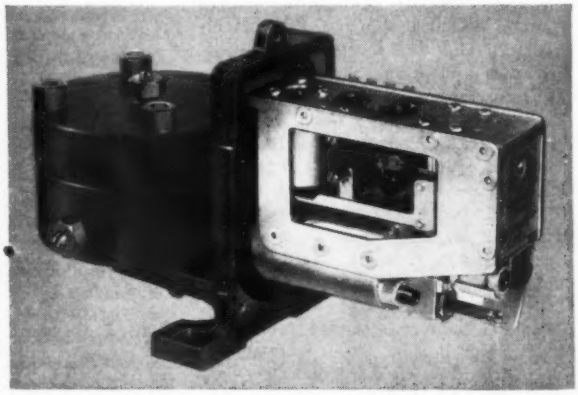


Fig 2 A Swartout d.p. transmitter. The differential transformer is in the small vertical cylinder in the centre

however, in phase quadrature with the working signals and remains substantially constant with changing core position. Since phase-sensitive rectification is employed in the receiver, and further, as will appear, the transmitted signal is always compared with a signal developed by a similar

transformer in the receiver, negligible measuring error is contributed by this residual effect.

In practice the complete transformer unit (see fig 2) is about 1½ inches long by 1 in. diameter, the input supply being of the order of 100 volts r.m.s. at mains frequency. Maximum output of 0·5 volt r.m.s. is obtained for a core movement of 0·050 inch. An output impedance of about 1,000 ohms renders transmission line loading errors negligible, and adequate screening from external fields is provided. Because of its essentially symmetrical form the unit is reasonably free from temperature effects and, combining linear response to small displacements with simple and robust electrical and mechanical construction, it forms an ideal transmission component for mounting in remote situations which may be completely inaccessible for long periods.

Primary measurements

Measurements of physical variables normally observed by displacement of diaphragms, etc., are conveniently transmitted by direct connexion of the differential transformer unit to the moving member, either with or without mechanical amplification of the motion as necessary. Thus simple pressures or differential pressures relating to levels, flow rates and other variables may be measured and transmitted by means of the instrument shown in fig 2. The displacement of the diaphragm within the pressure body on the left of the illustration is transmitted through a seal to the entire mechanism where the motion, balanced by a spring extension, is measured by the differential transformer.

Certain parameters, e.g. temperature, are customarily measured and transmitted in terms of d.c. signals, and for

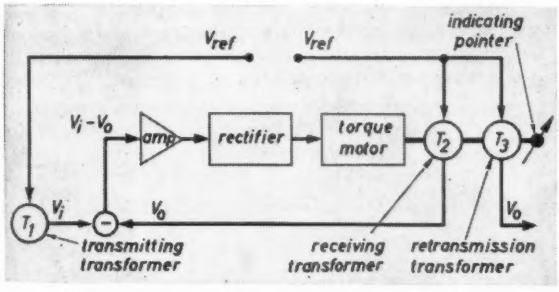


Fig 3 Operation of the receiving indicator or recorder

control purposes it is convenient to accept d.c. signals into the present system. For indication or computing purposes however, it is necessary to convert to a.c. and this is accomplished by a device resembling a moving-coil milliammeter in construction. In addition to the d.c. winding, however, the rotor of this device also carries a winding which is centrally disposed between two static a.c. energized coils, so arranged that they provide an a.c. field parallel to the normal rest position plane of the moving coil. The additional rotor winding therefore gives zero output in this position. Any deflexion of the rotor, which will be proportional to the current in the d.c. coil, produces a linearly dependent a.c. output signal which is compatible with signals from the differential transformer(s) described.

Indication and recording

The Swartout indicator utilizes a high-gain a.c. amplifier whose rectified output drives a torquemotor having a restricted angular rotation. This is used to drive a pointer through a gear train, and either one or two differential transformers. The complete arrangement is shown in fig 3. The amplifier causes the motor to rotate in such a way as to reduce the error voltage at its input and, since the gain is high, equilibrium is reached when V_o—V_i is very small, that is, when the outputs and therefore the displacements of the transmitting and receiving transformers T1 and T2 are identical within the system accuracy. The motor rotation and thus the pointer indication is then proportional to the transmitted measurement. The second driven transformer T3 is available for retransmission or computing purposes. It will be observed that, since both T1 and T2 are supplied from a common reference source, changes in voltage and frequency, unless they are significant enough to offset the amplifier performance, cause negligible error in reading accuracy.

Replacement of the pointer by a moving pen carriage

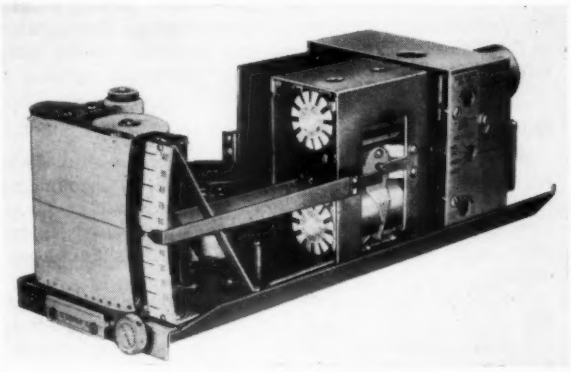


Fig 4 Complete recorder removed from its case

and inclusion of a chart mechanism provides a recorder which operates on the same principle.

Indicators and recorders are made as standard-size miniature panel-mounting instruments, convenient for use on graphic panels or where a large number of indications is necessary. Higher recording accuracy may be obtained by using a variant of the familiar 10 in. chart self-balancing recorder with its slide-wire replaced by a differential transformer mechanism.

Control

In order to provide operating signals to the various valves, solenoids, contactors, etc., whose manipulation controls the process under observation, the control equipment must be capable of accepting preset signals corresponding to desired working points, alarm level settings, loop stabilizing terms etc. In general each plant or process will require completely different computational procedures to be carried out upon the preset and measured information signals. The unit type of construction of the controller used in the present system enables a variety of differing requirements to be handled, the individual units being simply plugged into a mounting box, which itself may be attached to the rear of the panel-mounting indicator or recorder.

As the majority of industrial control appliances operate from d.c. signals it proves convenient for the system controller, following acceptance and comparison of a.c. input information, itself to operate in terms of d.c. signals. This also simplifies the derivation of integral and rate stabilizing terms.

A major difficulty in the use of electrical transmission for control purposes has in the past been encountered in the operation of large valves where considerable forces are required for rapid action. Both the disadvantages in the use of hydraulic or pneumatic transmission lines, and the slow response of electrically motorized valves may, however, now be avoided with recently developed electro-

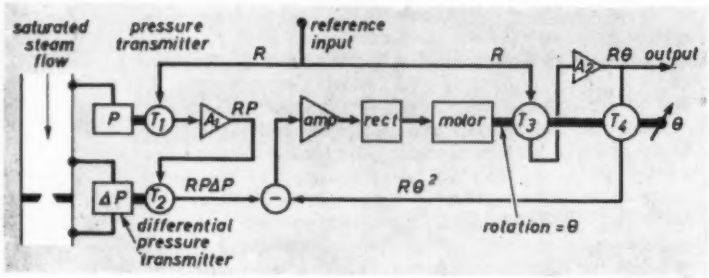


Fig 5 Linear measurement of steam flow

hydraulic mechanisms. These new valves employ a self-maintained supply of hydraulic power and are thus capable of the highest response speeds, only their pilot valves being actuated electrically by a remotely-transmitted signal.

Nuclear plant control examples

It is interesting to conclude by considering some actual examples of unusual plant control processes encountered in the nuclear field, where it has been proved that the instrumentation schemes described, with very simple extensions, have been sufficiently flexible to satisfy the requirement.

One of the features of the differential transformer is that the output voltage depends linearly upon the amplitude of the primary excitation in addition to the core displacement. When the two parameters are allowed to vary independently the output will represent their algebraic product, thus providing a useful operational facility.

The problem of steam flow measurement in the nuclear power plant differs from the conventional in that the difficulties of rapidly changing the heat output rate from the reactor to cope with electrical load transients force the station designer to tolerate large changes in the steam system pressure, whereas in the coal- or oil-fired station this parameter is maintained constant.

The variations in system pressure affect the measured pressure drop across an orifice plate for any given flow rate, and though instruments are available which supply a correction factor their working range is limited to within 20 pct or so of full system pressure. However, the differential pressure varies according to the square of the flow rate, and for control purposes a linear indication would be desirable. The relationship for saturated steam is:

Mass Flow $= K \times \sqrt{\text{System Pressure} \times \text{Diff. Pressure}}$

where K is a constant depending on the pipe and orifice sizes. Fig 5 shows a method of providing a linear flow signal using the system elements described. Both pressure and differential pressure are measured, and transmitted by T1 and T2 respectively. T1 is excited from the reference supply of amplitude R so that the transmitted signal corresponds to the product of R and the pressure P. This signal is next fed to T2 via the amplifier A1, which is necessary to restore the signal level and provide the required power, and is a simple feedback amplifier of defined gain. The output of T2 now represents the product of R, P, and the differential pressure $\triangle P$, and is connected to the indicator or recorder input. The two differential transformers T3 and T4 are connected serially to the reference supply, utilizing a second amplifier A2 similar to A1. Thus if the equilibrium angle of rotation of the motor is θ, the output from T4 returned to the instrument input represents the product of R and θ^2.

Under these conditions we have:

$$R\theta^2 = RP\triangle P$$

or $\theta = \sqrt{P\triangle P}$ which is always proportional to flow. Thus the pointer or pen position, θ, gives a linear indication of flow rate, and in addition an electrical signal is provided at the output of A2.

The above shows that the pointer indication is independent of variations in the value of R, yet the electrical output signal ($R\theta$) depends on R in the same way as all other electrical signals in the system.

A second and slightly more involved problem is concerned with the measurement and control of CO_2 coolant flow to the reactor. Here the CO_2 may be treated as a perfect dry gas obeying the gas laws for variations in the temperature and pressure to which it is liable in the plant. The full relationship between mass flow and other variables is then:

$$\text{Mass Flow} = K\sqrt{(\text{Diff. Pressure} \times \text{Density})}$$

$$= K\sqrt{\frac{(\text{Diff. Pressure} \times \text{Pressure})}{\text{Absolute Temperature}}}$$

involving division by absolute temperature.

A means of computing this parameter is illustrated in fig 6, where similar components and symbols are used.

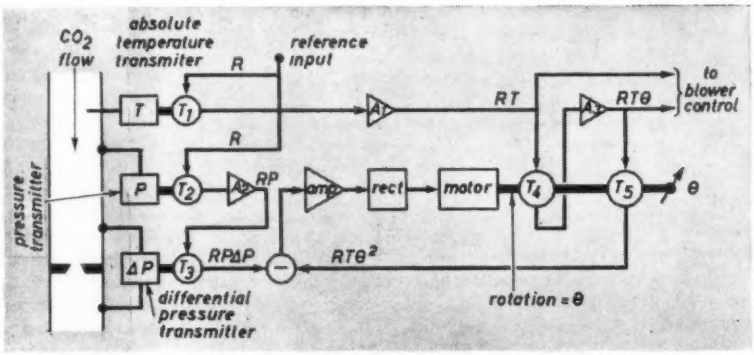


Fig 6 Linear measurement of carbon dioxide coolant flow. Note how another variable, T, has been introduced and how a control signal can be taken to the blower motors

the temperature transmitter employing the d.c. to a.c. converter described.

From the diagram:

$$RT\theta^2 = RP\triangle P$$

or $\theta = \sqrt{\frac{P\triangle P}{T}}$ which is always proportional to mass flow. Hence an indication or record of mass flow which is independent of variations in R is again obtained. In this case, however, no electrical signals exist directly proportional to θ, but the signals RT and $RT\theta$ from A1 and A3 respectively may be compared in the CO_2 blower controller unit by a similar process of division so that θ, the mass flow parameter, is derived.

References

1. Jervis, M. W., 'Telemetering Systems for Power Reactors', *Nuclear Power*, 1958 (Jan), p 6

Last month's article in this series of two dealt with thermal gradient transfer. This second type of transfer—a chemical process—is more complex

MASS TRANSFER IN LIQUID METAL SYSTEMS

2. Isothermal transfer

J. W. TAYLOR, PhD
Research Department, Babcock & Wilcox Ltd

A. G. WARD
AERE, Harwell

MANY OF THE REACTIONS occurring between solids and liquid metals may be interpreted in terms of two basic types of mass transfer: (i) Thermal Gradient and (ii) Isothermal. A previous article (*1*) has outlined the former, including the basic steps involved and experimental methods of study, and isothermal mass transfer processes are now considered similarly.

In isothermal, or chemical gradient, transfer the free-energy change responsible is the decrease accompanying the reaction of a solute in the liquid metal with a second solid in contact with the solution (fig 1). Thus the essential steps in this process are: —

1. Solution of solute element(s) (A) into the liquid metal. The source of the solute (A) may include a pure metal, a component from an alloy, a pure blanket gas, impurities (e.g. oxygen) in an inert gas, etc.
2. Transfer of the solution from (1) to the site of reaction with solid (B) either by forced (i.e. pumped system) or natural convection. In the latter case convective effects might arise from density variations in the solution accompanying changes in solute concentration or from temperature differentials in the case of systems not truly isothermal.
3. Reaction of the solution from (1) with solid (B). The reaction product may take a number of forms, e.g. solid solution, intermetallic compound, oxide, carbide, etc.

Thus the essential conditions for this type of transfer are: —

a. a free energy of reaction between solid and solution greater than the free energy of formation of the solution, and, as a corollary of (1),
b. a finite solubility, however small, of a solute (or solutes) in the liquid metal.

EXPERIMENTAL METHODS OF STUDY

Comparatively few specific experimental studies of this type of transfer have been made and methods of study are not clearly defined. The following broad classification is possible.—

Can or bulb tests

Metallic can studies of isothermal transfer employ in essence a unit of similar form to that shown in the previous article (i.e. fig 2 of ref (*1*)), with the can acting as the source of solute or as the second solid, i.e. (A) or (B) respectively of fig 1; an additional second solid must be incorporated into the can before closure, e.g. by attachment to the can lid. The assembled can is heated isothermally at some predetermined temperature and the course of the transfer followed radiographically and by subsequent metallography.

A glass-bulb technique, employed by the authors (*2*), is shown diagrammatically in fig 2. The two solids ((A) and (B) of fig 1), in rod form, are assembled vertically by means of the glass rod and spacer shown in fig 2 (a); these may be given any desired surface treatment beforehand. The liquid metal is filtered round the assembled solids and the lower glass bulb is sealed off under vacuum, fig 2 (b); this bulb is then heated isothermally at some predetermined temperature. After reaction the solids and liquid are separated by inversion of the bulb, fig 2 (c), and the form and extent of transfer can be studied metallographically; some such specimens are referred to below. For tests at higher temperatures silica capsules may be used.

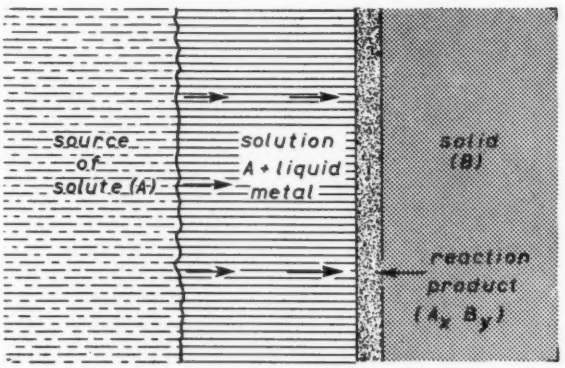


Fig 1 Also called chemical gradient transfer, isothermal transfer involves three basic steps

A more elaborate apparatus of this type was used by Baus *et al* (*3*) in the study of the isothermal transfer, in liquid sodium, of radio-active components from irradiated stainless steel to non-irradiated material; this work is referred to below. The activated sample is held at the bottom of a stack of similarly shaped discs of non-irradiated material in a sample holder and the non-irradiated discs can be progressively removed from the liquid bath via an inter-lock system and the degree of activity-transfer mea-

sured; samples of the liquid metal bath may also be taken in a similar manner by means of a bucket arrangement.

Loop tests

No specific tests of this type have so far been made of isothermal mass transfer but dynamic loops similar to those outlined when discussing thermal gradient transfer could

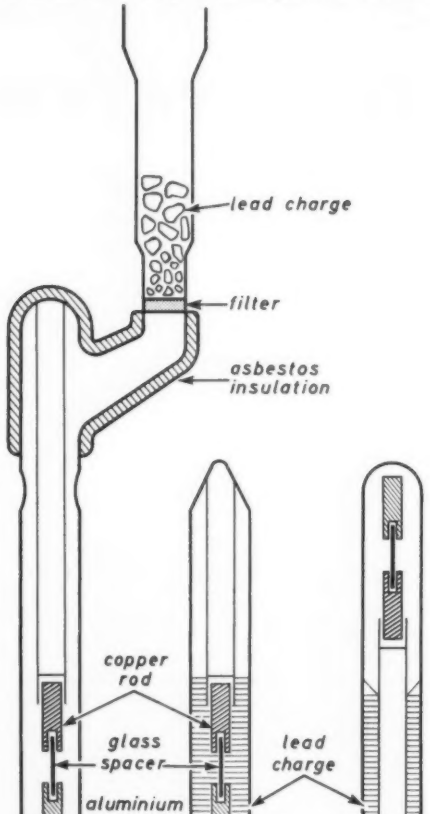


Fig 2 (a) the two metals are separated by a glass rod and filtered molten lead introduced into the bulb. (b) the bulb is vacuum sealed. (c) after isothermal heating it is inverted to study the effect of transfer on the specimens

equally be used if the operating expense were justifiable; this has never been so to date. Since such loops would require no temperature differential, they could be correspondingly simplified by the elimination of the heat exchange unit; such loops could be quite small since the only conditions governing the loop size are adequate space for a pump and separation of the solute source and reaction site (see fig 1).

STAGES AND EFFECTS OF VARIABLES

As outlined above the basic steps involved in this type of process, fig 1, are:

i Solution of solute element into the liquid metal

ii Reaction of the solution with a second solid (B)

While lack of experimental data precludes a detailed discussion the following general features may be outlined.

Solution stage

There would appear to be no basic difference between this stage in isothermal transfer and the corresponding one involved in the thermal gradient case (*1*), and the features outlined in that connection apply equally well. This holds for the kinetics of dissolution of a pure solid into the liquid metal and for the influence of dynamic conditions, temperature, etc. on these kinetics; as regards the influence of solid surface films, the leaching of alloy constituents, etc., the same remarks are applicable.

Reaction stage

On the basis of available experimental evidence it is possible to differentiate two separate types of reaction stage depending upon whether the metal with which reaction takes place, i.e. (B) of fig 1, is soluble or insoluble in the liquid metal. In the latter case he reaction of the solute metal (A) with (B) is initiated on the surface of the latter and results in a surface layer of adherent reaction product (A_x B_y). When the solute element (A) is metallic (as opposed to metalloid) this product may consist of a solid solution, a single phase, or a series of intermetallic compounds depending on the phase relationships of the system (A—B) at the temperature in question. The kinetics of the build-up of such a reaction product are likely to be governed by diffusion of the elements (A) and, or (B) in the reaction product(s) and the effect of temperature will probably be similar to that on diffusion rates in the solid reaction product(s). Likewise in the isothermal transfer of the metalloids, carbon, oxygen, nitrogen, etc., a surface layer of carbide, oxide, nitride, etc. will initially be formed on the surface of the insoluble reactant (B); subsequent growth of this surface layer will be controlled by solid-state diffusion. The mechanical stability of such surface reaction products, i.e. as regards their adherence to the solid surface, may be expected to vary widely. Where intermetallic compounds are formed this stability will be greatly influenced by the volume changes accompanying such compound formation and by any registry which may exist between the lattice of the solid metal (B) and the reaction product(s). Practical factors which are likely to influence such adherence are dynamic conditions in the liquid metal and wetting effects between the reaction products and the liquid; both would tend to promote the separation of the reactant and the product.

In those systems where the reactant is also soluble in the liquid metal a different form of reaction zone can be envisaged, depending on the relative supplies of the reactants (A) and (B). Where the rate of solution of (B) into the liquid is comparable to that of the solute (A) then the reaction to produce the compound (A_x B_y) is likely to be in the liquid phase taking place some considerable distance

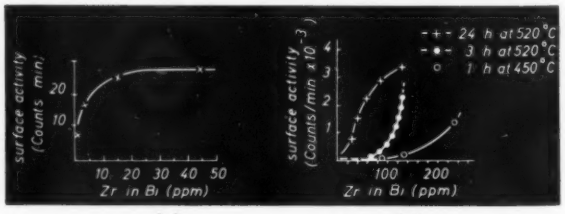
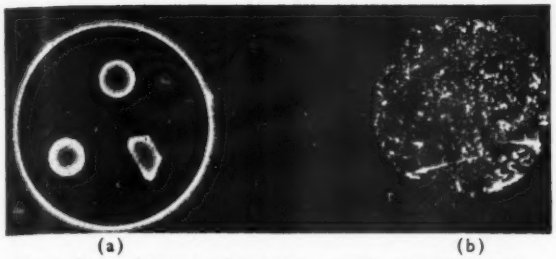


Fig 3 Zirconium-95 deposition on steel. (a) the initial stages: (b) the subsequent film growth

from either solid (A) or (B). In such systems the effect of temperature and velocity will be quite different from those in which a surface reaction product are formed and where the influence of solid state diffusion is strong. Their main effect would be to increase the solubility and rate of solution of both (A) and (B) in the liquid while their direct



(a) (b)

Fig 4 Autoradiograph of graphite crucible with Pb-Bi solution containing 1–5 pct U after reaction at 1200°C. (a) without zirconium; right (b) with 0–3 pct Zr (Ref 6)

influence on the liquid-phase reaction between (A) and (B) would probably be quite small.

OBSERVED ISOTHERMAL TRANSFER EFFECTS

Metalloid transfer in liquid sodium

In liquid sodium systems the isothermal transfer of the metalloids, oxygen, carbon, and nitrogen is well established from practical experience.

Thus metals such as uranium, thorium, beryllium, niobium, zirconium, etc, which form oxides thermodynamically stable relative to the solution of oxygen in liquid sodium, oxidize by an essentially isothermal mass transfer process when exposed to liquid sodium containing trace impurities, i.e. 5—200 ppm, of dissolved oxygen. The oxygen source, i.e. (A) of fig 1, may be oxides in the system reducible by sodium, leakage through welds, etc, or impurities in the inert gas blanket. The kinetics and variables affecting such oxidation processes have not been given detailed study. Siege (*4*) states that the weight gain by zirconium in oxygen-bearing sodium is essentially independent of oxygen content provided the latter is above 50 ppm; at 500°C this rate is 0·04 mg/cm²/month but drops by a factor of four at oxygen levels <50 ppm. He assumes that the kinetics of the oxidation of zirconium in liquid sodium will be the same as that by gaseous media once the oxide layer is formed but the evidence does not bear this out exactly. Mogard (*5*) has made a brief study of the rate of oxidation of uranium in oxygenated sodium and at 600°C gives a rate of 30-100 mg/cm²/month. In the case of beryllium no figures have been given for the oxidation rate in sodium but it has been reported that the oxide, which is protective under static conditions, is readily broken off in dynamic circuits.

The transfer of carbon via liquid sodium to metals forming stable carbides is also a well established type of isothermal transfer; in this case the carbon source may be graphite, plain carbon steel or other alloy containing carbon in loosely bound form, thermodynamically; it is not perfectly clear yet whether this carbon dissolves as such in sodium or whether some slight oxygen contamination is also necessary to permit its transfer in some more complex form. Siegel (*4*) studied the isothermal transfer of carbon from graphite to stainless steel and zirconium and some of his results are presented in Table I.

The observed effect of temperature on the extent of transfer to the two materials suggests that the reaction rate of carbon dissolved in sodium at any temperature is considerably lower with zirconium than with stainless steel, in spite of the zirconium carbide being thermodynamically much more stable than any of the carbide constituents in stainless steel. This difference in kinetic behaviour may be due to the formation of a discrete zirconium phase at the sodium/zirconium interface through which zirconium or carbon must diffuse for the reaction to proceed; no such discrete phase will form in the case of the stainless steel

TABLE I Carbon transfer to stainless steel and zirconium

temp (°C)	wt. change in graphite (%/mth)	capsule material	remarks
450	+0·06	S.S.*	no effect on capsule
525	−0·02	,,	,,
600	−0·40	,,	moderate carburization of capsule
675	−7·5	,,	heavy carburization of capsule
750	−50·0	,,	,, ,,
900	−50·0	,,	,, ,,
600	0	Zr	no effect on capsule
750	−2·8	,,	slight carburization of capsule

*S.S.—stainless steel—18 pct Cr, 8 pct Ni, 1 pct Nb

and the diffusion rate of carbon is probably higher in this metallic solution than in the zirconium carbide.

Nitrogen has also been reported transferring in a similar way through sodium to a hot stainless steel surface.

Growth of inhibitive films in bismuth and mercury

It has been established (*6, 7*) that the thermal gradient transfer of steel components by liquid bismuth or mercury can be significantly reduced by the use of 'inhibitors,' consisting of calcium or magnesium plus titanium or zirconium to the extent of 250-500 ppm. each. Work at Brookhaven National Laboratory (*6*) and at Harwell (*8*) indicates that

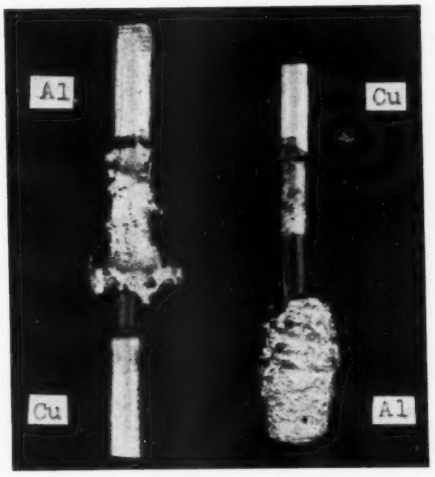


Fig 5 Forms of mass transfer deposit on copper-lead-aluminium system after 20 hours at 460°C (app. act. size)

the action of such inhibitors is due, in part at least, to the formation of a surface film of the thermodynamically stable zirconium or titanium nitride (or mixed carbide and nitride), the zirconium or titanium being dissolved in the liquid metal while the metalloids are present in the steel containing vessel.

Some data on the kinetics of this type of transfer process have been published (*6*) in the case of the growth of the inhibitive film on steel immersed in inhibited bismuth; the radio-active isotope Zr-95 was used to follow the build-up. The initial stages, fig 3 (a), appear to correspond to an absorption of the zirconium onto the steel surface, this process being complete at a zirconium content of about 10 ppm after one hour at 450°C. Subsequent film growth, fig 3(b), is a function of time, temperature, and zirconium concentration and will be influenced by the rate of diffusion of nitrogen, and, or, carbon through the steel to the

surface and thereafter by the diffusion of zirconium and, or, metalloid in the surface film. Steel compositions may influence this film growth stage in so far as elements in the steel, forming stable nitrides and carbides, e.g. chromium, aluminium, etc. may retard the diffusion of the metalloid element to the surface with a consequent influence on film growth rate and repair.

A similar inhibitive effect has been found in the case of graphite exposed to a lead-bismuth solution containing 1·5 pct uranium. At 1100°–1200°C (*6*) the uranium reacts with the graphite to form a solid surface layer of uranium carbide at the expense of the uranium in solution. If an 'inhibitive' charge of zirconium, e.g. 0·3 pct is added to the uranium solution, a thin layer of the thermodynamically more stable zirconium carbide forms preferentially and no uranium loss from solution occurs. These effects are shown clearly in fig 4. The left hand autoradiograph, fig 4(a), shows uranium carbide formation, as a halo, round the crucible and three graphite rods when zirconium is absent; while fig 4(b) is the autoradiograph, of a similar charge with zirconium added, shows a uniform distribution of uranium in the solified lead-bismuth alloy.

Activity transfer from stainless steel in sodium

An interesting type of isothermal mass transfer process of considerable technological interest involves the movement of the isotopes Ta-132, Mn-54, Co-60, and Fe-59, all emitters of hard gamma-rays, from irradiated stainless steel via liquid sodium to non-active areas of the same material. The practical significance of this transfer is that in stainless steel reactor systems containing sodium, regions

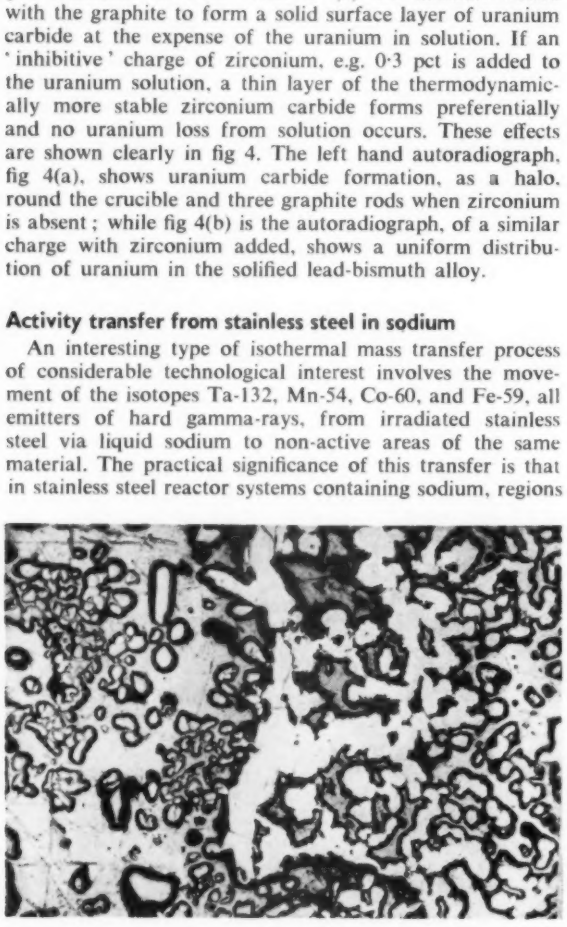


Fig 6 Microsection of copper-aluminium deposit in lead. Aluminium-rich compounds to the left: copper-rich compounds to the right (x108)

which might normally be expected to be inactive, become highly active even although they are not in the core region; an active primary cooling circuit is the result.

The following features of this type of transfer have been established (*3*):

a. Of the transferring constituents cobalt and tantalum are present as impurities, e.g. 710 and 880 ppm respectively, while Mn-54 is thought to arise from Fe-54 by an (n, p) reaction.
b. Slight changes in the composition of the surface on which deposition takes place do not significantly affect the transfer rate.
c. The specific activity transferred per unit area of receiver surface is proportional to the area of the active source and inversely proportional to the area of the receiving surface.
d. The transfer rate is dependent on oxygen contamination in the sodium (Table II). The addition of 1 pct of a de-oxidant such as barium, strontium, calcium, or magnesium reduces the transfer rate significantly.
e. The activity transferred increased exponentially with the temperature of the sodium; a thermal gradient in the system has no discernable effect on the transport rates.
f. The effect of time on the transfer of activity was not clearly established.

TABLE II Effect of oxygen on the transfer of radioactive components by sodium

Element	Transfer rate (microgram/cm²/month at 495°C) 30 ppm O in Na	100 ppm O in Na
Fe	2·5	40
Co	0·2	1
Ta	1·0	4
Mn	7·2	26

These several features may be understood on the basis of the following hypothesis. The components involved have minute solubilities in sodium, some values determined by Baus *et al* (*3*) being given in Table III; these solubilities are initially dependent on the oxygen concentration of the sodium, removal of oxygen reducing the solubilities below detectable limits. This accounts for (d) above.

TABLE III Concentration of components in sodium at 425 C

Component	Concentration (g/g of Na)*
Co	1×10^{-11}
Ta	3×10^{-10}
Fe	1×10^{-8}

* O content 300 ppm

When a solution of these active components in liquid sodium contacts non-active stainless steel exchange of the dissolved active isotopes takes place with the corresponding in-active ones as the result of the dynamic equilibrium between a saturated solution and its solid solute; on this basis the extent of the deposition would be expected to be proportional to the concentration of the active component (*8*). Since the solute solubility usually increases exponentially with temperature effect (e) above is explained. The area effects are difficult to explain on the basis of the available data while the variable effect of time, point (f), may be related to whether or not the transferred activity remains on the surface of deposition or actually diffuses into the substrate. The fact that temperature differential does not seriously influence the rate of transfer in this case is at first surprising since a solubility effect is involved (*1*). It may be, however, that the solubilities, i.e. 10^{-8}-10^{-11} pct, and their change with temperature are so small as to make transfer by normal thermal gradient means improbable. Certainly the actual mass of material involved in the present case is minute and there would be little chance of a deposit of any physical extent being produced.

Metallic phase-forming transfer

Where two solid metals, forming thermodynamically strong intermetallic compounds in the solid state, are bridged by a liquid metal, compound formation has been observed in practice particularly at higher temperatures (>500°C). Thus Manly (*10*) has found that a nickel beryllium compound forms on the surface of beryllium immersed in sodium also in contact with nickel, in spite of the negligibly small solubility of either metal in liquid

sodium. The authors have studied (2) some features of this type of transfer in the system solid copper-liquid lead-solid aluminium which appeared to have the necessary thermodynamic properties, i.e. simple solution of the copper in the lead and stable intermetallic compound formation between copper and aluminium in the solid state. The tests were carried out in the glass ampoule arrangement shown in fig 2.

Two forms of the deposit in this system after 20 hours at 460°C are shown on a macroscopic scale in fig 5; in both cases the deposit has formed round the aluminium while the copper specimen has obviously been reduced in size due to solution. Where the aluminium was positioned vertically above the copper, deposition has resulted in a plug forming across the entire section of the glass containing vessel (left hand sample of fig 5), whereas in the inverse position the deposit round the aluminium is more uniform (right hand sample of fig 5). When copper dissolves in lead the resulting solution is less dense than pure lead resulting in a convective rise of the solution vertically and this fact influences the physical form of the deposit. On a microscopic scale the deposit had the form shown in fig 6 from which it was apparent that the deposit was by no means continuous with, or completely adherent to, the aluminium. At least two of the copper-aluminium compounds could be detected; in fig 6 the aluminium-rich component is on the left in smaller discrete areas while the copper-rich one is to the right in a more massive form. The form of the deposit suggests that it formed by a liquid-phase reaction between aluminium and copper dissolved in lead rather than by any type of surface reaction; the relative quantities of copper and aluminium in solution would probably determine whether an aluminium-rich (initially

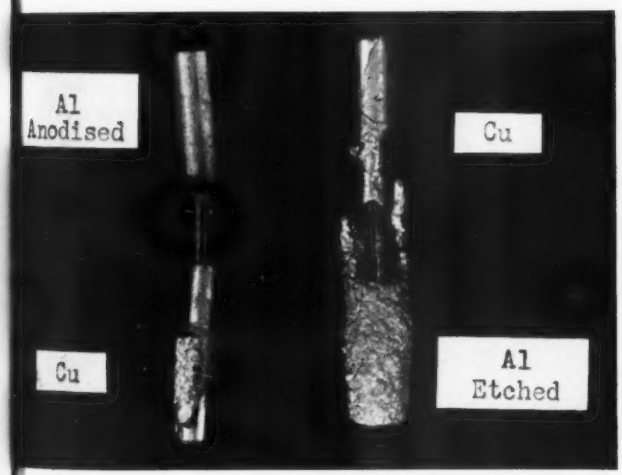


Fig 7 Effect of anodic film (left) on the transfer of copper to aluminium by liquid lead (approx actual size)

and close to the aluminium) or a copper-rich phase (latterly and further from the aluminium) would be formed at any time. This proposed mechanism is substantiated by the effect on the process of an anodic film on the aluminium; fig 7 compares the deposit on an unanodized aluminium specimen after 20 hours at 460°C (right hand sample) with that on an anodized one for a similar period (left hand sample). There has been no detectable deposition round the anodized specimen even although the form of the copper specimen indicates that there has been considerable dissolution of that metal into the lead.

Some indication was obtained on the kinetics of this transfer process for the geometry employed by determining the rate of weight loss of the copper over a period of 18 hours at 460°; this data was compared with solution-rate data for copper in lead at 460°C determined independently for a similar geometry under static (*9*) and dynamic conditions (*11*). These kinetic data for the transfer and for solution under both static and dynamic conditions are presented in fig 8. Thus the rate of weight loss of the copper at 460°C in the transfer tests is similar, over the first twenty minutes, to the rate of solution of copper when the latter is rotated at 0·05 ft/sec in lead. This would suggest

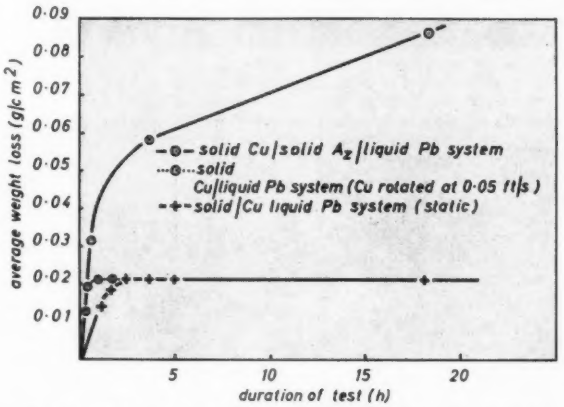


Fig 8 Kinetics of isothermal mass transfer—static and dynamic conditions

that in this initial stage of the transfer the rate-determining step is that of solution of copper in lead. After one hour the rate of loss of copper decreases significantly from its initial value and this combined with the observation that the lead was now saturated with copper, indicates that from then on the rate of the liquid-phase reaction determines the overall transfer rate. Such metallic phase-forming transfer is at present being studied in greater detail by Covington, Woolf & Geach (*12*).

CONCLUSIONS

Isothermal mass transfer is a second type of transfer process in liquid metals, the other being thermal-gradient transfer. In general it involves the transfer of a component from a source via a liquid metal solution to a reaction site usually near a second component, the driving force for the transfer being a free energy change of reaction; the solubility of the transferring in the liquid metal need only be very slight. The form of the reaction product and its location depend upon the phase relationships between the transferring component and the reactant, and between the latter and the liquid metal. The kinetics of the transfer will be complex and will be influenced by such factors as system geometry, form of reaction product, source of transferring component, etc. Surface films may seriously influence the transfer in so far as they may affect the source of the transferring component and also the reaction stage.

Acknowledgments

These articles on mass transfer were published with the kind permission of the Director, AERE, Harwell.

References

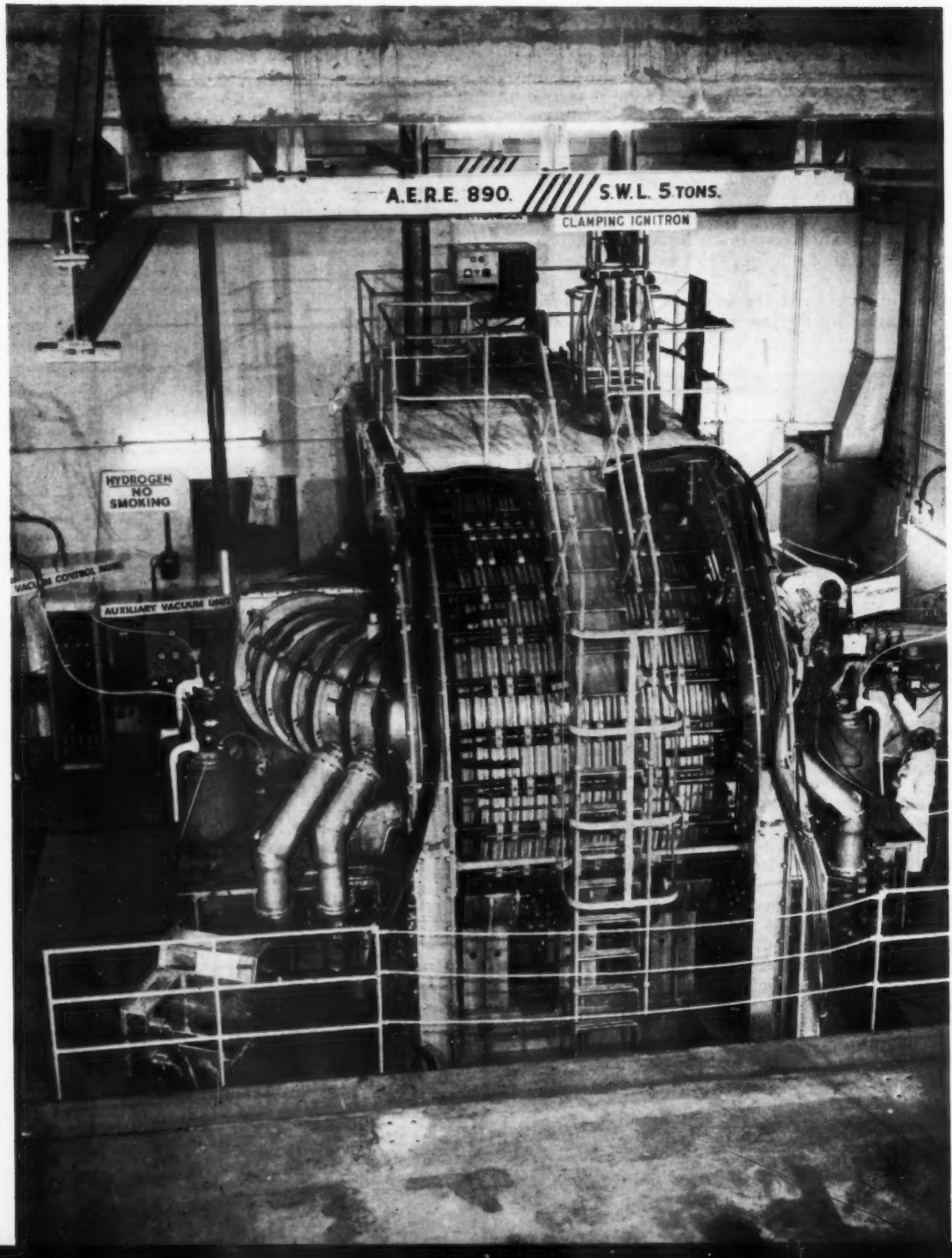
1. Taylor, J. W., *Nuclear Power* 1958, Vol. 3 (22), p. 50.
2. Taylor, J. W., and Ward, A. G., AERE Rep. M/R2296, 1957.
3. Baus, R. A., *et al. Proc. Intern. Conf.* (Geneva), 1955, Vol. 9, p. 356.
4. Siegel, S., *et al., ibid.*, Vol. 9, p. 321.
5. Mogard, H., *ibid.*, Vol. 9, p. 318.
6. Weeks, J. R., *et al., ibid.*, Vol. 9, p. 341.
7. Reid, R. C., *Amer. Soc. Mech. Eng.*, 1951, Paper No. 51-5-13.
8. Horsley, G. W., Private communication.
9. Ward, A. G., and Taylor J. W., *J. Inst. Met.*, 1956-57, Vol. 85, p. 145.
10. Manly, W. D., Private communication.
11. Taylor, J. W., and Ward, A. G., *J. Inst. Met.*, 1957-58, Vol. 86, p. 36.
12. Covington, A. R., Woolf, A. A., and Geach, G. A., Private comm.

THE MEN Here are four of the principal members of the team that have put Harwell right into the lead in thermonuclear research. D. W. Fry, Head of the General Physics Division and now Deputy Director of Harwell—the ZETA project comes under this Division. P. C. Thonemann, Chief of the Gas Discharge Physics section. R. Carruthers, Group Leader for the engineering of ZETA. R. S. Pease, Group Leader on gas discharge physics.

FRY

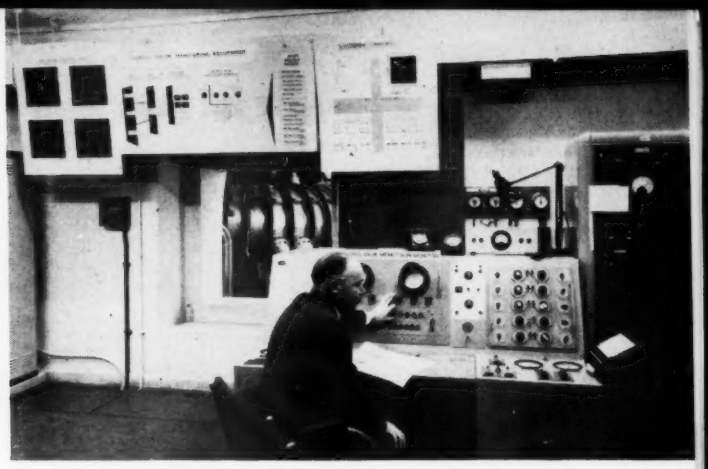
THONEMANN

CARRUT



CARRUTHERS

PEASE



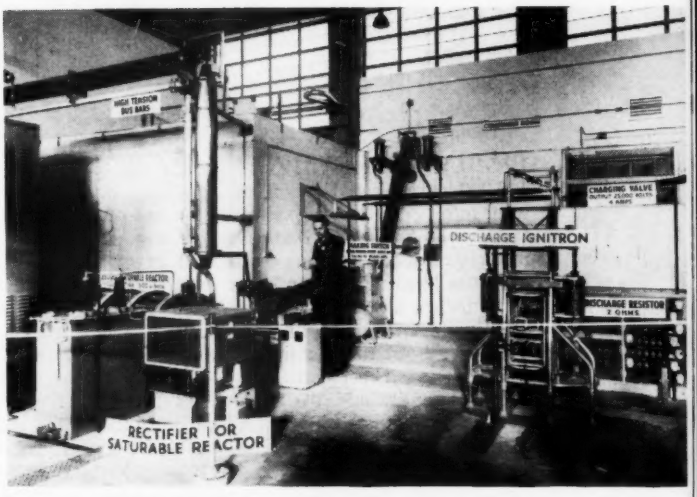
Here is the control desk—E.P. Butt in charge. The two cathode ray tubes are actually 'Memotron' storage units on which records of voltage and current in the discharge remain until erased. Details of this appear in this month's 'Companies.' On the wall are photographic records of discharges, whilst through the hole can be seen the torus

ZETA

The Men and the Machine

THE MACHINE Here it is on the left, To recapitulate—a full account appeared in last month's NUCLEAR POWER—it consists of a 1-inch thick aluminium torus or doughnut, 1 metre in diameter and formed to 1·5 metres mean radius. The shell is fitted internally with aluminium liners and is in insulated sections to prevent induced currents causing short circuits. The torus passes through the primary windings, the laminated iron core of which weighs about 150 tons. Deuterium in the torus is maintained at a pressure of about 10^4 millimetres of mercury and is kept slightly ionized by the radiofrequency equipment seen on top of the machine near the back. When a current pulse is applied to the primary—note twin busbars rising from the top—the ionized gas forms a short-circuited secondary circuit of one turn and a current of about 200,000 amperes is induced. This pinches the gas into a filament, or plasma, on the centreline of the torus and the combination of adiabatic compression and ohmic heating produced temperatures of several millions of degrees for a few thousandths of a second. To keep the plasma in the centre of the tube and stop it touching the walls, the torus is fitted with a number of coils in planes perpendicular to the centreline. These produce an axial field of about 200 gauss and effectively keep the plasma where it belongs. Other features of interest in this view are the vacuum spectroscope (right) and the liquid nitrogen traps for the vacuum system (left).

ZETA is shielded on three sides and above by thick concrete, but when neutron yields begin to pose a hazard the fourth wall will be completed. It is interesting to note that much of ZETA consists of standard electrical components and cost only about £300,000 to build.



This is where the high voltage is prepared for the gas discharge. In the room at the back are located the battery of fifty-two 31 microfarad condensers which supply ZETA with 500,000 joules of energy for a few milliseconds. The next step with ZETA will be to modify this plant to boost the discharge. H. Whittle shows how it works

Temperatures in ZETA are measured in the spectroscopy laboratory. A trace impurity of oxygen or nitrogen is introduced to the deuterium and observations are made of the Doppler broadening of the spectral lines. From these observations temperatures can be deduced. Dr. S. A. Ramsden (right) and B. Gates demonstrate how it's done

Test rigs from materials testing reactors are cut up and examined in these five interconnected hot cells. Operations are performed remotely with pairs of master slave manipulators and a power manipulator for which the control console can be seen in the background

DISMANTLING HOT TEST LOOPS

—a new Harwell facility

HIGHLY RADIOACTIVE materials up to a level of 100,000 curies can be handled in a new building which went into operation at Harwell at the end of January. The facility will be used to dismantle test loops taken from the materials testing reactors DIDO and PLUTO and to prepare the irradiated components for detailed examination. It comprises a series of five interconnected hot cells each fitted with remote handling gear. Designed as a workshop facility and not for chemical operations, the new building is thus intended to be an intermediary between the reactor and the scientist, and it is operated by the engineering division under Mr J. E. Bown. A similar block in the same building is planned for levels up to 10kc for use by Harwell scientific divisions.

Immediately after removal from the reactor core, a test rig would have an activity level of about 5×10^5 curies and would be left for two days or so to cool down to the acceptable level of 10^5 curies. Loops up to 12 ft by 1 ft can normally be handled by the facility but with special arrangements even more bulky equipment can be taken inside the cell line. It would usually arrive at the loop entrance in a 20 ton lead-shielded flask and be unloaded on to a hand-propelled bogie by a 25 ton overhead crane. The bogie runs on rails passing through all five cells. After it has been taken into the transfer bay the outside doors of the bay are closed, forming a sealed area, and the flask can be transferred into the first cell.

Extra thick cell walls

Each cell is 8 ft in useful internal width, 10 ft 6 in. deep and 16 ft 6 in. high. The enclosing walls are 5 ft 6 in. ordinary concrete, chosen instead of dense material on economic grounds. Partitions between the cells, however, are steel tanks filled with steel-shot concrete of density 350 lb/cu ft which reduces the necessary thickness to 2 ft. Part of each partition forms a sliding door, weighing 30 tons, which can be driven electrically through the rear wall into the frogmen operating area to allow free passage for the test rig between the cells. The buttress partition can also be jacked out to follow it. This gives operational flexibility to the plant and means that the cells can be arranged in 8, 18, 28, 38 or 48 ft units. As a general rule the first two cells will be used as one 18 ft module.

Remote handling

Operations in each cell are carried out remotely with pairs of Savage and Parsons master slave manipulators. Running on rails over all five is a 1½-ton electric travelling crane and a General Mills power-assisted manipulator. Both are powered by cables fed out from drums on the cell roof and can be controlled from each cell panel. To allow the crane and the manipulator to pass to each cell, the top part of each partition wall consists of a hydraulically operated drop door. Capable of lifting 700 lb on hook, the GM manipulator has three crane motions, continuous rotation of the 'wrist,' and upper arm and forearm motions. It has five step speeds and audio load warning; movement is controlled by two hand levers on the control console in the operating area. Operations are viewed through a specially designed shielding window in each cell measuring 5 ft wide by 3 ft high, and matched to the wall thickness. They comprise seven glass laminations and a zinc bromide tank on the operator's side. These are mounted in reinforced epoxy resin called 'Resilon' with a fibre-glass laminate. Very bright sodium lights have had to be installed in the cells as the windows' light absorption is about 50 pct.

For passing heavy items down the cell line from the first cell, a magnetically-controlled bogie is provided with a capacity of 5 tons. This is controlled remotely from the operation area by an electric loop round the guiding rail which magnetizes it in either direction. This operates corresponding magnetic relays on the bogie itself, moving it either forward or backward.

Individual cells are devoted to one stage of the opera-

tion. In the first two the loop is removed from the flask and then cut to release the fuel element or whatever reactor component it contains. Radiographic equipment is installed to prevent the test sample being damaged during the opening. The loop cutting machine makes two circumferential and two longitudinal cuts. In the third cell there is a milling machine, metrological inspection will be carried out in the fourth, and physical testing in the fifth. Equipment can be posted out from any cell through concrete and lead plug doors into the maintenance area behind the cells—operated by frogmen—or pass into the second transfer bay and then through the three decontamination bays. Weighing eleven tons, the plugs are operated by hand ratchet. Waste material in containers is buried underground in the frogmen area as a temporary operational storage.

After each operation the cells are cleaned by the manipulators to a reasonable gamma level, when frogmen enter through the plug doors and reduce the contamination still further. The six frogmen are directed from a central control room fitted with intercom and men can also speak to each other. Here the pay-out of the men's hoses is controlled and there is an alarm system for failure in air supply. Stringent precautions are taken in washing the frogsuits after every use and in keeping the inside free from contamination after the helmet has been removed. Over the frogmen area runs a 10 ton hoist.

Balanced ventilation system

Spread of contamination from the cells and the cell-service area to the operating areas is prevented by a carefully balanced ventilation system. Air flow is directed at all points towards the areas of higher activity; pressure in the cells is maintained at 0·7 in. w.g. and in the frogmen area it is 0·3 in. Incoming air is blown by a single fan through a bank of Vokes type 44 filters fitted with paper filters. The output plenum comprises ten Vokes 55 filters capable of handling a total of 10,000 cu ft/min. Air enters the cells from the ceiling and is extracted through the floor via another Vokes 55 filter. Servicing of the extract filters and disposal of the contaminated filter material is performed by the frogmen on the roof of the cells, to which there is easy access by stairs from the maintenance area.

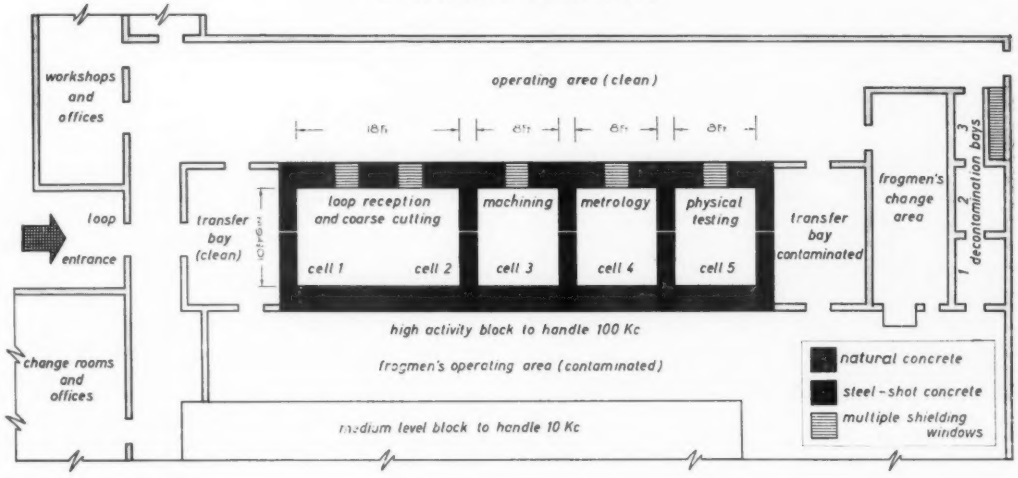
Design emphasis throughout has been on easy operation and maintenance, and quick turnover. Simplicity is the keynote of all operating gear, especially in the frogmen area, and where possible equipment for use in the cells is preassembled in the building's workshop.

After each operation, cells are cleaned to tolerance level by frogmen. Blurred effect in shielding window at right is due to multiple reflexions in the seven glass laminations

Firms concerned in the project were:

ANDREW MACHINE CONSTRUCTION CO LTD: *Ventilation plant*
JOHN BARNSLEY & SON LTD: 10 *ton and* 1½ *ton electrical cranes*
CHATWOOD MILNER LTD: *Handling bogies*
W. E. CHIVERS & SONS: *All civil engineering*
CLECO ELECTRICAL INDUSTRIES LTD: *Remote controlled bogie*
FELLOWS BROS LTD: 25 *ton crane*
GENERAL MILLS INC: *Power manipulator*
MATTHEW HALL & CO LTD: *Cell steelwork, doors; piped services*
MENDIP CHEMICAL ENGINEERING LTD: *Fibre-glass window tanks*
POWERHOUSE COMPONENTS LTD: *Cable rules*
REID & PARTNERS LTD: *Master slave manipulators*
GEORGE VERNON SALES LTD: *Metrology equipment*
VOKES LTD: *Air filtration of building and cells*
WESTERN DETAIL MANUFACTURERS LTD: *Cell benches etc.*

Ground floor plan of high activity building shows five hot cells and direction of flow



This is how complete uranium fuel plates are rolled in a two-high mill at Argonne National Laboratory. The fuel for APPR is actually uranium dioxide sintered with tungsten dioxide, a small amount of boron carbide to act as a burnable poison and stainless steel powder. The sintered plates are then clad with stainless, hot rolled to bond them, and then cold rolled to final size

Stainless steel cladding is used in preference to zirconium in successful small US reactor

APPR Fuel Elements

fabrication technique

FUEL ELEMENTS for the Army Package Power Reactor, Fort Belvoir, Va, contain enough fuel to operate the reactor continuously for 18 months at the full thermal power of 10,000 kW. The core design is essentially unchanged from that originally proposed by the Oak Ridge National Laboratory, the fuel elements being arranged in a 7 by 7 array with the corners missing, and with seven of the 45 positions occupied by the control rods.

In establishing design criteria, ORNL selected stainless steel and uranium dioxide as the construction and fuel materials. Boron, in the form of boron carbide, was added as a burnable poison to increase core life. A minimum thickness of stainless steel cladding is required because of its excellent corrosion resistance in pressurized water. It seems likely that the stainless steel APPR fuel elements will not only advance the technology of pressurized water reactors, but may be a major factor in economical power production in remote locations.

The fuel unit proper is 27 inches long. It is designed to contain eighteen 0·030 in. thick composite fuel plates, one above the other, but spaced 0·133 in. apart to permit cooling of the plate by flowing water. The sixteen inner fuel plates are 23 in. long; they are designed to permit insertion and attachment of end fittings to all positioning of the fuel elements in the reactor-grid plate. A pin is attached to the bottom adaptor and a spring to the top adaptor to assist in fixing the position of the fuel element in the reactor.

Powders cold pressed

Oak Ridge selected type 304L stainless steel as the wrought cladding with ·07 pct maximum carbon 304B stainless for the fuel core matrix. They chose a dense uranium dioxide, in the size fraction of 44 to 88 microns, as the fuel material, and boron carbide as the burnable poison to be mixed intimately with the fuel oxide. The fuel core of the composite plate is prepared by adding 28·62 g of WO_2, 0·188 g of B_4C and 99·80 g of stainless steel powders. These elements are inserted in a small glass container, and a number of these containers are placed together in an oblique blender. After blending, the mixture is inserted in a die and pressed under 33 tons per square inch to form the fuel core for the composite plate. When a number of cores have been accumulated, a batch is sintered in a

After the cores are clad with stainless steel they are preheated in a hydrogen muffle furnace before rolling

After hot rolling the composite fuel plates are annealed before the final cold roll

hydrogen atmosphere at 2150°F. Each core is again placed in the die and coined in final size. Advantages of individual preparation, as against the possibly more economical batch blending, are accurate accounting of the uranium and boron and excellent homogeneity.

Once formed, the coined fuel cores are inserted in blanked frame plates; covers are attached to each side of the frame; and the plates fabricated into composite fuel plates. They are preheated in a hydrogen muffle at 2100°F and rolled to a 91 pct reduction in thickness. During rolling, the stainless cladding is metallurgically bonded to the stainless-steel core material. The clad fuel is then reduced to its final dimensions—22 in. long, 2·5 in. wide and 0·020 in. thick—by cold rolling. After locating the fuel core by fluoroscopy, the plate is marked, sheared, and machined to a width of 2·776 in., thus allowing for an inactive steel protective edge along the length of the core.

THE REACTOR

APPR-1 was described in NUCLEAR POWER in March 1957. Of the pressurized-water type it uses enriched fuel and is used to drive a 2 MW turbogenerator. It was designed and built by Alco Products Inc of Schenectady to meet an Army requirement for a reactor the components of which are all small enough to be transported by air to remote locations. APPR first delivered power on April 15, 1957 and was officially inaugurated on April 29. In July of last year it satisfactorily completed a 700-hour type test, with only 8 hours out; during this, it delivered more than 1000 MWh and demonstrated its inherent safety and stability. The core contains 38 fuel elements each formed from 18 plates of the type described in this article. Control is by boron-10 carbide rods attached to the upper ends of seven additional fuel elements. The rods are operated from below by rack-and-pinion so that the effect of a scram action is to lower a fuel element out of the core and replace it with a poison section.

Reactors based on this general design but of larger size are to be built in the UK by Humphreys and Glasgow Ltd, London, who concluded an agreement with Alco in 1957.

Assembling plates

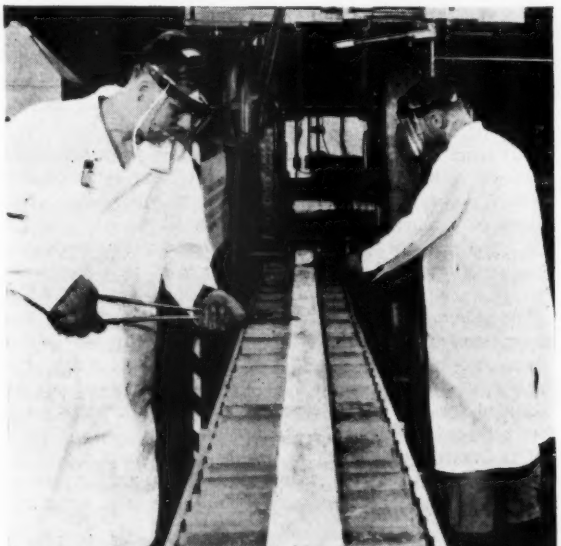
Once annealed, the plates are assembled into a fuel array in a stainless steel fixture designed to confine the fuel unit during assembling and brazing. After each plate is individually positioned, a thin layer of powdered Coast Metals NP braze metal is applied dry at the joint between the fuel and side plates and is fixed in position with Nicrobraz Cement. A thin strip of Colmoney Green Stopoff is added alongside to prevent lateral flow of braze metal onto the cladding above the fuel section of the plate. Combs are attached to each end of the unit to help maintain spacings between plates. The assembled fuel unit is now brazed in a protective hydrogen atmosphere, slowly and uniformly heated to 2066°F, and then furnace cooled. Following this, the unit is thoroughly cleaned in hot water. Then all critical dimensions, including spacings between plates, are measured, thus maintaining tight specifications requiring no additional machining. In fact, though specifications permit a 10 pct deviation of the nominal plate spacings, approximately 95 pct of the units brazed were held within 5 pct.

Final steps in completing the fuel assembly are *Heliarc* welding of end adapters to the fuel unit, machining the end adapters, and attaching the pin and spring. After thorough degreasing, the fuel element is ready for shipment.

Fuel elements for the APPR will probably be returned to a government facility for recovery of U-235.

Satisfactory tests

Several tests have been developed which indicate the functional qualities and in-service reliability of the fuel elements. The stainless steel matrix of the fuel core may be embrittled during irradiation, but this effect can be reduced by using UO_2 particle size of 44 to 88 microns, thus permiting a larger volume of stainless steel between the particles. This conclusion is supported by the test of a full-sized APPR element irradiated in the lattice of the MTR to an average burn-up of 25 pct of the U-235 atoms. No visual damage was apparent and later microscopic examination revealed no significant effects.



At Sylvania-Corning Nuclear Corporation uranium metal strip is cold rolled

Another prototype element passed severe testing at Westinghouse Atomic Power Division for more than 6000 hours under conditions simulating those in the Submarine Thermal Reactor. Here the corrosion of either stainless steel or the Coast Metals NP brazed joints proved negligible. There is every indication that the stainless steel fuel element will meet the service requirements of irradiation and corrosion resistance expected in the APPR.

Harwell has now had about eight years' experience of beryllium working and has developed the safety methods described here

BERYLLIUM HANDLING

—reducing the health risk

R. O. R. BROOKS, Medical Division, AERE Harwell

THE ADVANTAGES of beryllium as an alloying material and the superior ceramic properties of its oxide are being increasingly recognized in industry. In addition, both metal and oxide find use as neutron reflectors and as moderators in nuclear energy projects. Uranium fuel elements are canned in beryllium, the metal makes an ideal window for X-ray tubes, and with radium or polonium it provides a neutron source for the initiation of pile fission processes.

The toxic nature of beryllium and its compounds has been generally recognized within the last ten years, and its physiological effects have been discussed elsewhere (*1*). Apart from dermatitis and lesions resulting from beryllium retention in skin cuts (both avoided by wearing protective clothing), the hazard is entirely one of inhalation. The degree of toxicity is affected by factors such as the particle size, type and form of compound, the calcining temperature in the case of oxide preparation and, to a lesser extent, by variations in individual susceptibility.

The United States Atomic Energy Commission has recommended that the average concentration in air for the 8-hour working day should not exceed 2μg Be/m^3 and, further, that an upper limit of 25μg Be/m^3 should not be exceeded for any period however short. These levels have been adopted at Harwell.

The inhalation of dust or fumes of the metal and its compounds can be controlled by liquid damping or, better, by the provision of adequate extraction at the operative site.

The purpose of this paper is to discuss and recommend, for the benefit of prospective users, precautions so far successfully applied at AERE, Harwell, over the last eight years for the handling of beryllium and its compounds. Although the scheme to be outlined is based on an industrial laboratory scale, the same general considerations apply to any size of plant undertaking beryllium processing.

Building design

The precautions taken should be designed to prevent the incorporation of beryllium or its compounds into the body even in minute amounts. Design of a building should therefore be such that the possibility of beryllium release into the air both inside and around the building is remote.

Entry to the building should normally be through the changing rooms only. Massive equipment can, where necessary, be introduced through a double-doored emergency exit. The changing rooms should be divided into a 'clean' and a 'dirty' section separated by showers, and ample locker space provided in both sections. Washbasins (preferably with foot or elbow-operated taps) will also be required in the 'dirty' section. It is an advantage to have separate washing and showering accommodation for maintenance men employed on the extract and filter plant to limit the spread of any dust produced during filter changing.

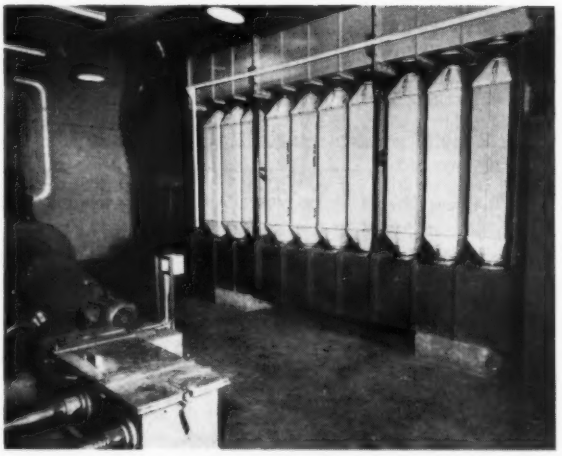


Fig 1 Air from fume cupboards and hoods is passed through this bank of filters to prevent the discharge of particles into the outside air. Each filter contains cotton-asbestos material and when exhausted is capped, sealed and buried. The plant on the left feeds steam-heated air into the laboratories at a rate slightly less than that extracted, thus maintaining a small negative pressure

Adequate storage space for equipment should be allocated in the original design. It should be incorporated in the main structure and should not be less than one tenth of the total volume of the building. If the building is long and narrow, a store at each end is desirable. If a workshop is included in the scheme, it will require its own storage area. Each store should be adequately provided with shelves—the lowest being well off the ground to allow easy cleaning of the floor—and a close-fitting, sprung door installed to reduce dust contamination from the working area.

Provision should also be made within the building for a fireproof safe or store large enough to accommodate all stocks and working amounts of beryllium. Although neither beryllium nor its compounds are pyrogenic, in the event of a fire there is the possibility that powder release by convection may occur in quantities large enough to con-

stitute a hazard to the firemen and personnel in adjacent buildings. There is the further risk that if the temperatures are sufficiently high, vaporization of the compound will occur. Livey and Murray (*2*) have shown that the volatility of beryllia is considerably increased in the presence of water vapour—a condition to be expected during fire fighting. This reaction is likely to occur even with compacted forms of the oxide, and on this account it is advisable to keep powder stocks and compacts of beryllium and its compounds in a fireproof safe when not in use, material needed during the day being returned to the safe at night.

Interior finish

The interior of the building should be designed to facilitate easy cleaning. Crevices and open shelves should be avoided as these harbour dust. Floors need to be impervious to dust, and cleaning is simplified by coving the edges and providing faired corners. Good quality linoleum is very suitable as a floor covering as it can be easily washed and kept well polished, but care is needed in laying the strips to prevent gaps at the joints where dust could collect. If walls are finished in high-gloss paint, dust is kept at the surface and regular cleaning with detergent and water is easier. A plaster base to give a smooth finish is preferable, but a smooth-faced brick base can be used if it is necessary to keep costs low. All working surfaces should be impervious to dust and readily cleanable. Stainless steel, polished hardwood or slate, and linoleum have been found suitable, but the surface chosen must be free from cracks. Stainless steel is the best material for sinks.

Air purification

To prevent air within and around the building becoming beryllium-polluted, an adequate extract and filter system is necessary. At AERE, two separate extract plants are employed to give 20 air changes per hour in all laboratories of the beryllium building. Air is drawn through fume cupboards and hoods or supplementary ducts, and then through one of two banks of filters before stack discharge 20 ft above roof level. The cotton-asbestos units, designed by Hodge (*3*) are packed in dispensable metal canisters. Each unit passes about 180 cu ft/min of air. One of the filter banks is shown in fig 1. When the filter unit is exhausted, the canister is capped, sealed and buried. The Vokes 55 paper filter unit has been tested and also found suitable for this work. It is housed in a wooden container, and the whole unit can be incinerated if burial space is limited. Care must, of course, be taken to prevent release of the resulting vapours e.g. by collecting them in a liquid trap. Warmed air is fed into the laboratories through a plenum system at a rate slightly less than that extracted, thus maintaining a small negative pressure of 0·005 in.-0·010 in. w.g. throughout the building. In this way, possible beryllium leakage into the air outside through cracks in the building structure is avoided. Providing that the air conditioning is satisfactory, installation of non-opening, double windows is to be preferred. The possibility of leakage is then reduced, and the negative pressure within the building maintained should either one of the glass barriers be accidentally broken. A remotely-controlled sun blind can be situated between the two panes if required.

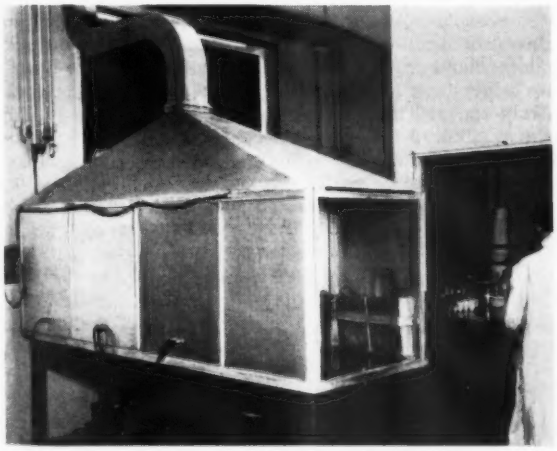


Fig 2 All enclosures, like this fume cupboard with stainless steel working surface and enclosure for polishing metal specimens, feed into the extract ducting

Fig 3 On-off dampers are fitted to the ball mill, unloading cupboard and sieving cabinet shown so that they can be isolated when not in use. Additional extract can then be made available for particularly dusty operations elsewhere

Protective enclosures

Various types of protective enclosure can be employed from the open fume hood to the completely enclosed glove box (see figs 2, 3 and 4). They are connected to the extract ducting, and if each is fitted with an on-off damper for isolation when not in use, additional extract is made available when required for particularly dusty operations. Presses should be fitted with adequate extract ducts, and hoods built around workshop machines to cover the area in which drilling, polishing, milling, cutting, etc., take place. The extent of the enclosure will depend on the particular operation e.g. low-speed turning of beryllium requires only a local, adjustable extract tube, while for cutting purposes necessitating a high-speed wheel, a complete enclosure with sliding front panel is advisable. An ample supply of connexions fitted with temporary caps should be installed at various points along the extract ducting. Additional enclosures can then be coupled to the extract without breaking into the ducting. As new processes are introduced, an increasing load is placed on the extract system

Fig 4 The telescopic extract hood can be lowered over the operational site when hot pressing or sintering beryllium in the vertical furnace shown

and it is an advantage to install plant with half as much capacity again as that initially required.

Dry sweeping hazardous

No procedure involving beryllium or its compounds in powder form (other than beryl ore) should be carried out in the open laboratory. Dry sweeping is strongly discouraged as a hazardous amount of airborne beryllium dust can be raised in this way. Sweeping with dampened sawdust is satisfactory but it is better to use a suction cleaner. The cleaner should be fitted with an outlet filter capable of retaining particles down to at least 0·1 micron radius unless the outlet is led into a fume cupboard or convenient point in the extract ducting. For ease in manoeuvrability, the filter method is to be preferred. In the workshop, the control of the dust and fine turnings produced can be achieved by laying these with the aid of the lubricating fluid necessary for many of the machining operations.

It should be noted that beryllium and its oxide are quite safe to handle in the open laboratory when in solid or highly compacted form providing that there is no removable surface powder. A potential hazard only exists when the metal or its compounds are in a sufficiently finely-divided state to become airborne as dust or vapour.

Decontamination can be accomplished by washing the area with Teepol and water followed by thorough rinsing. This treatment can be applied not only to equipment and fittings, but also to floors, walls and bench surfaces, and regular and frequent cleaning of the whole interior of the building in this way is advisable. Oil or paraffin should be used for machine parts or other equipment likely to rust.

Full protective clothing should be provided; this includes overalls, shoes, headgear, gloves and underclothes. The extent of changing necessary will depend on the particular operation. Thus a complete change is advisable for the operator engaged in powder work, whereas a laboratory coat and overshoes are suitable for the occasional visitor with minimum expected exposure. For the replacement of filters or when the extract ducting requires breaking into, a complete change of clothing and the wearing of a respirator (with D/8/41 Porton type filter) is essential. Smoking or eating in the "dirty" area should not be permitted. Thorough washing before meals and at the end of each shift should be encouraged, and a shower in cases where a complete change of clothing is necessary.

All contaminated clothing should be thoroughly damped before laundering, which is best undertaken at the works. The normal drainage system can be used, but all washings should be thoroughly flushed away to prevent the formation of a film of beryllium which might become airborne on drying. Thorough rinsing to remove all traces of dust in the clothing is essential in the laundering process.

Waste disposal

The disposal of beryllium waste can be effected by ground or sea burial, of which the former is likely to be the most practicable. A large pit is dug at the site chosen and the area suitably signposted both during and after filling. A layer of earth is used to cover each batch of metal containers into which the waste should be sealed. This can include both laboratory waste and workshop oily residues. Oil drums with enlarged mouths make very suitable containers. The pit should be used only for beryllium waste; it is particularly important to prevent burial in the same pit of pyrogenic materials which may be ignited by rain or damp, as beryllium particles may be released in the ensuing fire. Sink disposal of liquid residues or of small quantities of solid beryllium or its compounds in the laboratory is suitable providing that all particles are flushed away. Powder disposal in this way should be carried out in a fume cupboard sink. A settling tank may be required for recovery purposes on purely economic grounds.

Checking for contamination

Frequent air and environmental checkings for beryllium should be instituted. Air samplers should be used to check all beryllium processes and should be situated at the operator's breathing level and as close to the source as he is likely to be. The filter papers employed can be treated chemically and the beryllium content determined spectrographically. Alternatively, a direct-reading spectrographic monitor can be employed. Smear samples taken on filter papers from benches, floors and walls can be used to check that these surfaces have been adequately cleaned. The results obtained should not exceed 25$\mu g/m^2$ and should, preferably be less than 2$\mu g/m^2$. Plant can be similarly treated, and it is suggested that, for equipment leaving the building for maintenance, an overall figure of 25μg from the smear sample is not exceeded following decontamination of the items. If this figure is exceeded, further cleaning is advisable.

By continuous application of the two main principles for controlling dust emission, namely liquid damping and air extraction from the operative site, and with the cooperation of the personnel concerned, the hazards of beryllium handling in the industrial laboratory can be successfully overcome.

Acknowledgements

I would like to acknowledge the helpful advice and guidance of Dr Katharine Williams, Division Head, of Medical Division, AERE Harwell, in dealing with all problems of beryllium control since the beginning of the beryllium project at Harwell, and for suggestions in the compilation of this paper. In Metallurgy Division I would like to thank Dr H. M. Finniston, Division Head, and Dr P. Murray for reading the text, and Mr W. Munro for permission to take the photographs.

References

1. Williams, Katharine. *Industrial Chemist*, 1957, **33** (386) April.
2. Livey, D. T., and Murray, P., AERE M/R 1543.
3. Hodge, T. N., AERE ES/N3.

Motor controller for accurate speeds

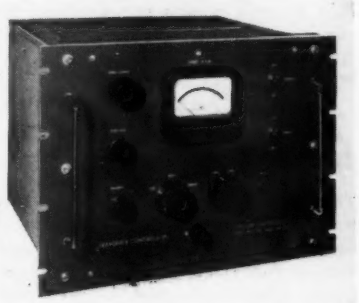
A new high precision motor controller —type M.C. 43—has recently been placed on the market by Servomex Controls. Designed for rapid reversal, it can be switched from full speed forward to full speed reverse in as little as 1·4 seconds and is therefore suitable for high speed production work.

This instrument provides a mechanical drive in a convenient form, the speed range available being much greater than that obtainable with any other form of control. Once set, the speed is maintained at a constant figure to exceptionally fine limits. It is suitable for operation with an input supply ranging from 200 to 250 volts, single-phase, 50-60 cycles and provides a range of speeds from 0 to 6,000 rpm which can be smoothly varied in either direction. An electrical tachometer on the control panel enables the operator to determine the motor speed with a guaranteed absolute accuracy of plus and minus 1·5 pct of full scale.

The torque produced is a minimum of 21 ounce-inches at all speeds and does not diminish at the higher speeds. Application of full torque does not cause a speed change of more than 6 rpm over the whole speed range. At constant torque, mains variations of up to plus and minus 7 pct from the nominal voltage and frequency do not cause any drift of speed greater than 5 rpm.

The instrument is built round a ⅛ hp, 6000 rpm d.c. motor coupled to a d.c. tachometer generator with an output voltage accurately proportional to speed. The generator voltage is compared with an electronically stabilised reference voltage and the error signal is amplified and used to vary the speed of the drive motor until the error is eliminated. The speed error cannot exceed a few rpm for more than a matter of milliseconds and a suddenly applied load is normally adjusted in about one-twentieth of a second. No electrolytic capacitors are employed and a delay switch and relay prevent premature application of the h.t. before the valves are sufficiently warm.

If required, provision can be made for remote operation. For certain applications requiring a range of different pre-



Plus 6000 rpm to minus 6000 rpm in 1·4 sec

set speeds, a switch—manual or automatic—can be provided to select these.

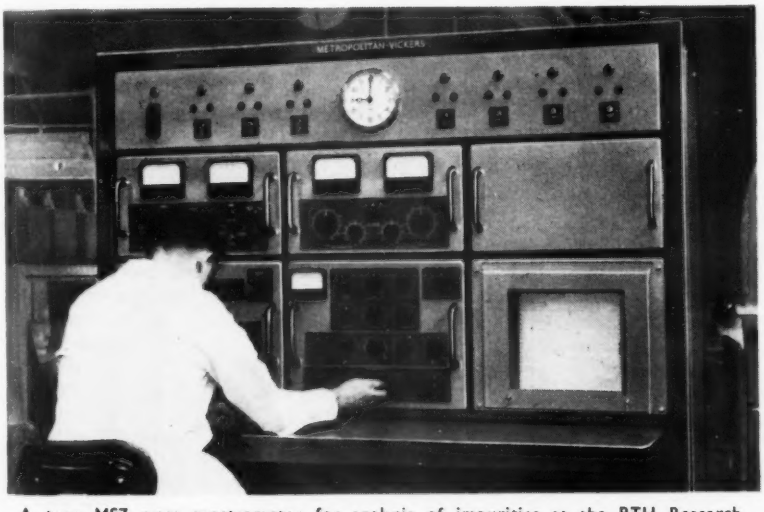
The control unit can be had for standard 19 in. PO rack mounting. In this form it is 14 in. high, 15½ in. deep and it weighs 88 lb.

Tick No 125 on reply card

Metrovick introduce two new mass spectrometers

Two new types of mass spectrometer have been designed by Metropolitan-Vickers for analysing inorganic solids—the MS5 for determination of isotope ratio using the surface ionization technique, and the MS7 for the analysis of impurities using the spark ionization technique.

The basic problem in solid analysis is to produce positive ions truly representative of the sample composition. A number of methods has been tried, one of the more successful being the technique of surface ionization. There are several slightly different versions of this, but in its simplest form the solid sample, in the form of a salt such as the nitrate or sulphate, is painted directly on to the surface of a tungsten filament. When the filament is heated, positive ions are emitted which are identified and measured using conventional mass spectrometric techniques. The technique is not particularly suitable for the general analysis of solids, because different elements have widely different sensitivities, but it is ideal for the measurement of isotope ratios of solids. The type MS5 mass spectrometer has been specifically designed for use on this problem.



A type MS7 mass spectrometer for analysis of impurities at the BTH Research Laboratories, Rugby

The machine is a 12 in.-radius 90°-sector single-focusing mass spectrometer for use with either the single or triple filament surface ionization technique. Two particular features of the instrument are (i) a sliding-bar vacuum lock system, which enables the sample to be introduced into the instrument in less than a minute, and (ii) an ion collector system, which provides for the simultaneous availability of a normal collector (noise level approx. 3×10^{-15} A) and an electron multiplier (equivalent noise level less than 10^{-18} A). A resolving power of at least 300 can be obtained.

Nearly 75 pct of all the elements respond to the surface ionization technique, including most metallic elements. The normal size of sample is a few micrograms, but with certain elements 10^{-11} grams will enable approximate determinations of isotope ratio to be carried out. The time required for an analysis varies from 10 minutes to 1 hour depending on the element and the sample size available.

The MS7 mass spectrometer A method of ionization of solids employing the vacuum spark is approximately equally sensitive for all the elements. However, the use of this technique requires a double focusing instrument because of the large energy spread in the ion beam produced. The MS7 instrument is designed for the general analysis of solids by the spark ionization technique. It is

a double focusing instrument of the Mattauch type, in which positive ions, representative of the sample composition, are produced when a high-voltage spark occurs between two electrodes formed of the sample material and placed close together in vacuum. After passing first through an electrostatic analyser and then through a magnetic analyser the ions come to focus according to their mass as a series of lines on a photographic plate.

One of the most promising applications of the instrument is to the analysis of impurities in solids. For this work the photographic plate is used as an integrating device, and a series of exposures of gradually increasing length are taken (a rack mechanism allows up to 10 exposures to be recorded on the same plate and the exposure is accurately determined by the total integrated charge falling on the monitor collector). The concentration of the impurity is estimated from the intensity of the lines on the longer exposures, and with this technique concentrations down to the level of 0·1 p.p.m. can be estimated.

The method is particularly useful for giving a general picture of the impurities in a solid. The whole mass range from 7–240, covering all elements, can be recorded in a single exposure of the photographic plate. Compared with emission spectroscopy the spectra are simpler and the elements easier to identify. Moreover, qualitative and semi-quantitative analyses can be carried out without extensive calibration.

Tick **No 126** on reply card

Aircraft flowmeter redesigned for land use

The Integral electronic flowmeter has now been in use for some time for measuring fuel consumption in aircraft, and this has resulted in enquiries from companies who require similar equipment for laboratory and industrial uses. Integral Limited have now produced a ground version of the flowmeter which retains the desirable characteristics of the airborne equipment while providing the greater flexibility necessary to meet the wide range of applications which are anticipated.

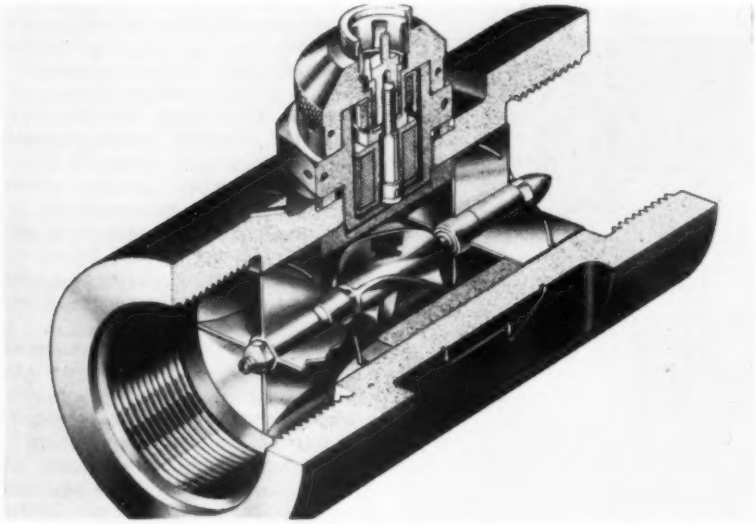
The apparatus consists of three units: (1) **The flow transducer,** fitted in the pipeline, which generates electrical impulses with a frequency proportional to the rate of flow through the pipeline. (2) **The electronic relay** which converts these impulses into a direct current proportional to the frequency. (3) **The indicator,** which is a moving coil meter calibrated to read directly in rates of flow.

The transmitter consists of a tubular body containing a flowtube assembly containing a four-bladed helical rotor. One blade of the rotor contains a magnetic insert, the opposite blade being counterbalanced. The bore of the flowtube is finished to an accurately-calibrated diameter, so that in operation the rotor makes a known number of revolutions during the passage of a unit volume of fuel.

The inductor assembly comprises an iron-cored coil in a housing screwed into the body of the transmitter so that the coil lies within the field of the rotor magnet. During flow of liquid, for each revolution of the rotor the magnet induces a signal pulse in the coil; the frequency of the pulses is thus proportional to the flow rate, expressed either volumetrically, or, if the liquid density remains constant, in units of mass.

The pulses are amplified, shaped and fed to a ratemeter circuit which produces a d.c. output proportional to the pulse frequency and thus to the flow rate. The calibration of the rate circuit is dependent upon the rates of flow to be dealt with, each electronic relay being individually pre-set. Where indicator calibration is in mass units, variations in the density of the liquid metered will result in errors in the readings unless compensated for. Different methods of correction can be employed where such errors are not acceptable; where variations are small, such as those due to temperature changes, a manual control can be provided; where large variations are met with (as when metering alternative liquids) switched ranges are used. Switching can also be employed where widely differing flow rates are to be dealt with by a single electronic relay. The standard indicator is a milliammeter having a full scale deflexion current of 1 mA, the type and grade being chosen to suit the particular installation and degree of accuracy of reading required. The dial may be graduated in any desired units.

Tick **No 127** on reply card



Flowmeter is an inferential type, revolutions of turbine runner being counted and recorded electronically

Improvements to Vacu-Blast machine

Seen at last year's Engineering, Marine, Welding & Nuclear Energy Exhibition was Vacu-Blast's new *Major* machine. Although it has been in production for a few months and several machines are now working on a variety of shot blast applications, this exhibition provided a venue for its general release to all branches of industry.

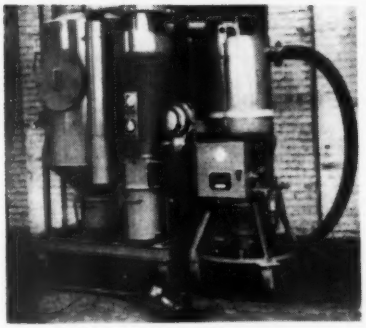
The *Major* is a modified and improved equivalent of the Vacu-Blast *Standard* machine. Although different in appearance from the now superseded *Standard* model, many parts are interchangeable, and all the attachments for use with the *Standard* can be used with the *Major*. The machine comprises two units—the generator-reclaimer and the dust collector and, like the *Senior* machine, these may be sited individually at some distance apart or they may be integrated to form a single unit. Lifting hooks are provided to enable the separate units or the integrated machine to be slung according to the needs of the work in hand. In the composite form the floor space occupied is only 7 ft. 7 in. by 3 ft. 6 in., the overall height being 8 ft. 2 in. and the weight 3,000 lb.

The generator-reclaimer section of the machine is now more sturdy and compact and a plug outlet is provided in the reclaimer section to enable quick re-

moval of debris. The dust collector is likewise more compact thereby facilitating operation and maintenance. Its cylindrical air filter unit now uses sock-type filters giving an increased cloth-to-air ratio thereby improving the efficiency of the final air filtration.

The *Major* can be supplied as a continuous cycling (C.C.) or a non-continuous (N.C.) unit. The former ensures a continuous supply of abrasive and is indicated where grit blasting must continue for several hours without interruption. The N.C. type however requires a brief interruption in blasting for approximately thirty seconds every five or six minutes and is recommended for all discontinuous grit blast applications.

To go with the new machine a smaller version of the *High Production Gun* has been introduced to meet the requirement of many whose output of steel plate for



Machine is in two units—generator-reclaimer and dust collector

mill scale removal may not warrant the larger *Senior* installation. In addition to the *High Production Gun* for plate descaling, there is the *Standard Gun, Long Gun* and *Small Gun* for vertical and overhead blasting; the dual gun for plate edge preparation and a selection of attachments for cleaning tubes from one-eighth inch bore upwards. Blast cabinets can also be supplied for cleaning intricate castings or the pass-through cabinet for cleaning structural sections, both of which are operated in conjunction with the *Major* machine.

In the few months since this machine was first made available it has been installed in shipyards for descaling heat-treated mild steel plate and grit blasting ships' hulls, on nuclear power sites for cleaning heat exchangers, in a steam turbine factory for cleaning steam and oil pipes, in a steel rolling mill for grit blasting work rolls, in railway repair depots for rolling stock maintenance and in a boiler shop for weld preparation in the fabrication of pressure vessels.

Tick No 128 on reply card

High-static d.p. gauges from KDG

New from KDG Instruments Ltd is a differential pressure gauge suitable for use with static pressures up to 150 psi. The main feature of the instrument is that with ranges from 0–50 in. w.g. it is capable of withstanding the full static pressure of 150 psi as an overload on either the high or low side of the instrument, without causing any calibration changes on returning to normal conditions. For ranges 0–25 in. w.g. to 50 in. w.g., overloading conditions of up to 100 psi can be accommodated. This refinement, which is achieved by a liquid-filled collapsible system, gives the instrument full protection against any line breakage or fault.

Basically the instrument consists of two parts—a rear pressure chamber which houses a capsule or diaphragm

Calibration stability after severe static overload is feature of new gauge

assembly, and an isolated indicator. The two are connected by a patented U arm and flexible diaphragm device. There is one pressure connexion to the capsule and another direct to the pressure chamber and the differential of these applied pressures causes the capsule to distend and operate the indicator through the aforementioned device.

The instrument is supplied in 6 in. or 7 in. indicator case, and is suitable for flush panel mounting. All parts in contact with the liquid or gas are non-ferrous alloys.

At the working static pressure an accuracy of ± 2 pct full scale deflexion at any point on the scale is offered, with a ± 4 pct accuracy over the complete static range.

Tick No 129 on reply card

New relief valve now generally available

Originally developed for Megator's well-known pumps, the valve can be easily dismantled without interfering with the pipework

A range of new relief valves, designed specifically for handling liquids, is being introduced by Megator Pumps & Compressors Ltd. Made of high quality bronze to BS 1400-LG3, the valves were originally developed for use with the well-known Megator pumps to protect the installation against excessive discharge pressure or faulty operation, but they are now also available to industry generally.

A particular feature of the valve is the introduction of a skirt to the clack, which makes the valve more positive and stable in operation. As soon as the valve begins to open, the skirt presents a greater area to take the pressure, so providing an increasing force to overcome the increasing resistance of the spring as the valve lifts. There is thus a smaller differential between the opening pressure, the pressure at which the valve will continuously discharge full capacity and the reseating pressure.

Other features are an arrangement to prevent unauthorized interference with the setting, and the ease with which the spring and valve disk can be dismantled for inspection or replacement without interfering with the main pipework. Freedom of movement of the valve disk can be speedily checked by removing a single screwed cap and turning the valve spindle. The valves can be dismantled and the clack and seat inspected without interfering with the setting.

The valve spring, of cadmium-plated

carbon steel, is outside the main body of the valve, so that it is not in direct contact with the escaping liquid. An "O" ring effectively prevents the escaping liquid leaking into the spring chamber.

The sizes and stock settings of the valves are as follows: 1 in. size has a setting of 65 psi; 1½ in., setting 65 psi; 2 in., settings of 36, 65, 110 and 150 psi; and 3 in., settings of 65, 110 and 150 psi.

Tick **No 130** on reply card

In Brief

New line of **contact meter-relays,** specifically designed for use in Wheatstone Bridge circuits, is announced by Assembly Products Inc., Chesterland, Ohio, USA. The resulting circuit gives control action on signal changes of 0·1 pct or less in the active leg of a bridge. Speed is less than half a second. Dials read 100-0-100, numbers expressing percentage of scale on either side of zero.

Tick **No 132** on reply card

Power-free, uninterrupted illumination for 10 years from '**atomic**' **lamps** is claimed for production models of *Isolites* by makers—United States Radium Corporation, Morristown, New Jersey, USA. They use radioactive krypton-85 gas which causes luminescence in special phosphors.

Tick **No 133** on reply card

Composite radiation windows weighing up to nine tons each are being made by Corning Glass Works. *Plexiglas* is used against neutrons: high density lead glass for gamma radiation.

Tick **No 134** on reply card

Two new diffused-base N-P-N medium-power **silicon transistors** were recently announced by Texas Instruments Inc., Dallas, Texas, USA. Differing only in collector-to-base and collector-to-emitter voltage ratings (60 and 100 volts), the transistors can dissipate 4 watts at 25° or 1 watt at 150°C case temperature. Saturation resistance is 20 ohms at 25°C plus an operating range of −65° to +200°C, with guaranteed stabilization to 215°C.

Tick **No 135** on reply card

Competition in world markets is behind introduction by AVO Ltd, 92 Vauxhall Bridge Rd, London, SW1, of new **pocket-size multi-range test meters**—*the Multiminor.* There are two models differing only in degree of tropicalization—Model 1 is for temperate: Model 2 for tropics. Mass production methods and printed resistors result in competitive price.

Tick **No 136** on reply card

Platinum laboratory crucibles of polygonal cross section have been introduced by Baker Platinum Division, 52 High Holborn, London WC1. Claimed advantages over conventional types are: more stable, easier grip for tongs, pouring spout opposite each flat, two crucibles can be picked up together. Price is same as for Baker's round crucibles.

Tick **No 137** on reply card

Remote-handling tongs for manipulating through shielding walls have been introduced by The Atomic Center Inc., 489 Fifth Avenue, New York, 17, NY. Similar to Harwell-type equipment and known as the *Ball-Swivel Radiarm,* the tongs are available with a variety of special, easily-replaceable heads.

Tick **No 138** on reply card

New from Elliott Bros (London) Ltd, Century Works, London SE13, is the 600-1800 range of **multi-channel recorders.** These use Elliott's miniature moving-coil recorder movements and can be arranged to record simultaneously on a single strip chart in banks of 2, 3, 4, 5 or 6 units, each instrument recording on a 3-in. wide zone. It was developed in collaboration with the Nuclear Power Plant Co Ltd.

Tick **No 139** on reply card

Lancashire Dynamo Electronic Products Ltd report they have received British Standards Institution licences covering the use of BS 'Kite' mark on their **smoke alarm and density indicator** series SM E2.

Tick **No 140** on reply card

Magnetic Devices Ltd announced that their series 590/596 relays can now be had with heavy duty contacts rated at 15 amps with a single-pole normally-open arrangement.

Tick **No 141** on reply card

A very compact **vacuum pumping outfit for semi-automatic operation** was recently supplied to a customer in Switzerland by Edwards High Vacuum Ltd. It comprises a rotary air ballast pump displacing 1·7 cfm backing a fractionating oil diffusion pump capable of 5×10^{-7} mm Hg. Control is entirely push-button through a 7 ft lead.

Tick **No 142** on reply card

Wayne Kerr Laboratories Ltd have two new products (1) **a wide-range audio-frequency oscillator** (type S 121) which provides a stable, controlled signal with the range 10 c/s–120 kc/s. (2) **a wide-band attenuator** (type Q 251) of high accuracy and stability for use in the frequency range 0–60 Mc/s.

Tick **No 143** on reply card

Three new **molybdenum disulphide, bentone greases** are introduced by Rocol Ltd—Molytone 265, 320 and 380. Applications broadly, are for slow, medium and high speed respectively. Prices are same as former single product.

Tick **No 144** on reply card

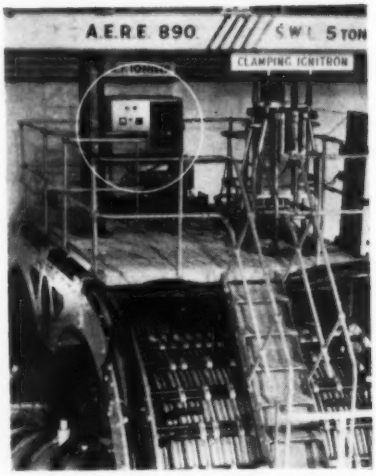
A new **multi-channel cathode ray oscillograph**—type MUR—has been announced by Southern Instruments Ltd. Two models are available giving up to six and twelve channels respectively with time marking.

Tick **No 145** on reply card

An entirely new model—the *Tektor Major*—of their well-known type of **capacity-operated level controller** has recently been introduced by Fielden Electronics Ltd. A sensitivity of better than 1·0 pF is claimed under all conditions. Performance of prototypes sent out to industry for evaluation trials on 'difficult' jobs have exceeded all expectations, say Fieldens.

Tick **No 146** on reply card

Keeping ZETA gas ionized



'Radyne' induction heater. 3½ kW model, modified for operation in ZETA

Performing an important job of work in ZETA is a *Radyne* induction heater. The Harwell engineers have taken a standard 3½ kW model and modified it, and are using it to provide a radio-frequency discharge in order to ionize the gas in the main toroidal tube of ZETA. By making the gas conductive it forms a short circuited secondary coil, the primary of which is the main winding around the toroidal tube.

It is of interest that this induction heater was primarily designed by Radio Heaters Ltd for industrial purposes of a varied nature, namely heat treatment, electronic vacuum work, soldering and brazing on the production line. Similar types of *Radyne* equipment are used for preheating plastic moulding materials, welding metals, and low temperature welding in the production of plastic clothing and fancy goods.

Tick **No 131** on reply card

Developments in fission product precipitators

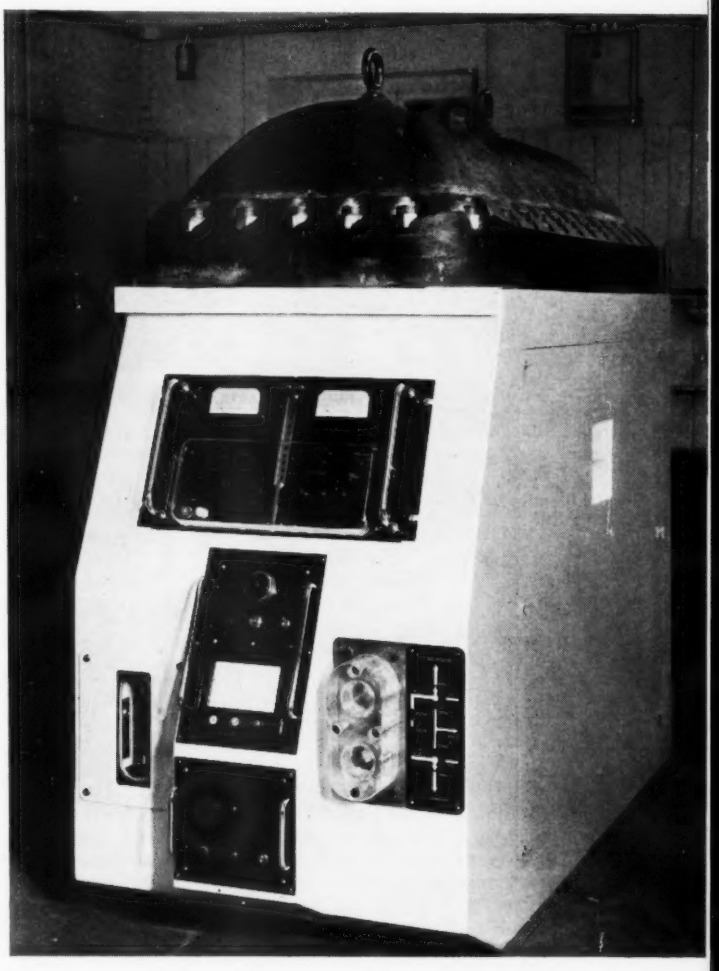
Big reduction in size expected in second round stations

THE PRESENCE of fission products in the cooling circuits of a gas-cooled power reactor indicates a punctured or ruptured fuel element and rapid detection and location of the fault is an essential design feature of the British type of nuclear power station. This is important not only from the safety aspect but also from the point of view of efficient working. All the current designs of first round stations use the well-tried Calder Hall system of fission product detection (FPD) or burst slug detection (BSD)* but considerable improvements are being made by the various groups specializing in this work. It was to see what Dowty Nucleonics Ltd are doing for the Berkeley station that NUCLEAR POWER recently visited the firm's headquarters at Brockhampton Park, near Cheltenham, where the design offices and experimental department are located. Here the prototype FPD equipment is assembled and is undergoing rigorous trials.

The firm believe that, although there are alternatives, the technique of electrostatic precipitation of solid decay products and the subsequent monitoring using a scintillation counter is without serious rival at present although its hardware tends to be inelegant and costly. Thus a great deal of effort is going into improving all aspects of performance and reducing the cost of the gear. This is not easy since the ever-increasing gas pressures of the new stations are tending to oppose both these aims.

Tests with real fission products

How seriously Dowty take this work can be gauged from the fact that they have installed a fission product generator which is believed to be the only one of its kind. The generator is really a sub-critical reactor assembly forming part of a gas loop. The assembly consists of a steel pressure vessel containing a stack of tubes coated with highly enriched uranium oxide through which air or any gas can be circulated by means of a small blower. The top cover of the pressure vessel contains a vertical thimble tube down which is lowered out of its transport container an antimony-beryllium neutron source which starts a convergent fission reaction in the uranium. On emerging from the pressure vessel the gas, now containing gaseous fission products, passes through delay tanks and filters so that it arrives at the precipitator unit in the decayed condition expected in a power station. Further delay tanks down-



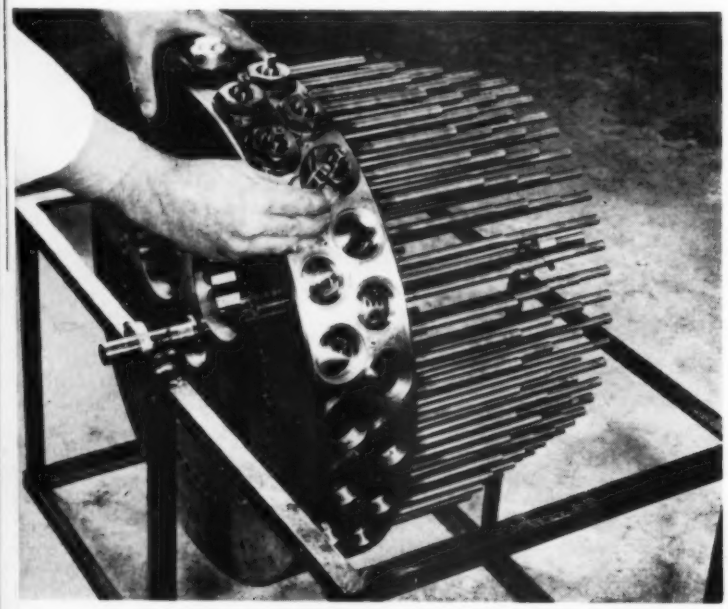
Precipitator units for Berkeley power station are essentially similar to those used at Calder Hall but in appearance they are rather different owing to the 'turbine casing' type of pressure vessel which has been adopted by Dowty to improve the accessibility

*The Atomic Energy Authority seem to prefer yet another designation—Burst Cartridge Detection (BCD).

stream of the precipitator allow the activity to decay sufficiently for the gas to be returned to the pressure vessel. The sub-critical assembly is shielded by concrete blocks laid dry. The firm regard this facility not merely as a convenient *ad hoc* test for precipitator schemes but also as a means for establishing fundamental parameters.

In the matter of FPD gear Dowty's responsibilities cover the whole installation apart from the display equipment. Thus the main items under development are selector valves, precipitators and counters, and compressors.

As at Calder, Berkeley will have one sampling pipe from each of its 3000-odd channels and for convenience these will normally be scanned in groups of four, a spot test



In the prototype Berkeley channel selector valve, manual selector cocks are assembled in the base ring. These are used to pick out an individual fuel element channel for special monitoring after a count on a group of four has shown some abnormality

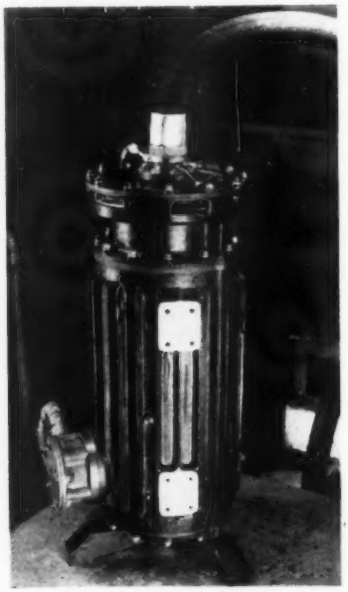
of a single channel only being called for after a high count from a group. Unlike some of the new stations which have manual selector valves near the reactor all the sampling pipes will come out into the FPD room where they will be connected to the combined manual cocks and automatic selector valves.

There will be 17 of these units, one for each precipitator, and each one receives 196 sampling pipes grouped in fours at the manual cocks. These have six positions: four pipes grouped, four pipes separately, and off. The valve bodies are bored radially in a forged stainless steel ring into which the sampling pipes are brazed, the cocks themselves being precision investment castings. The outlets from these cocks connect to ports on a common pitch circle in a flat hard-chrome-plated steel disk underneath the forging. Each hole is scanned in sequence by a hollow arm mounted radially on a hollow shaft which ducts the gas to the precipitator. The arm terminates in an annular carbon bush which is spring-loaded against the port plate. The selector arm is rotated by a ratchet mechanism, there being a carbon shaft seal where the shaft passes into the selector valve casing.

It will be recalled that the Calder precipitator units were contained in cylindrical pressure vessels closed at each end by cover plates. To make for greater accessibility and ease of maintenance the Dowty precipitator body is cast in two pieces which are bolted together in a horizontal plane rather like a turbine casing, the seal being made by a pair of O-rings.

All components are mounted from the base and as far as is practicable are designed to be removed as complete sub-units. The wire-storage drums, for instance, can be quickly bolted to a frame and can be removed and replaced, complete with wire, as a single unit. It is not anticipated, however, that frequent servicing will be required. Endless wire loops, on accelerated life-tests which are, if anything, more severe than normal operating conditions, now give effective lives of over a year. As compared with Calder Hall equipment, there are also considerable detail changes in the precipitation chamber and in the counter. As examples: in the latter, the beta-gamma discrimination has been improved, while in the precipitation chamber the provision of aerodynamic spoiling at the entry and exit ports has increased the efficiency of collection for moderate biasing potentials.

The basic dimensions of the Berkeley precipitators are essentially similar to those of Calder Hall but re-assessment of the problems involved has made it possible to make dramatic reduction in size in units now offered. This has been done without recourse to radically new principles and the design can be regarded as well-proven. The wire system is now so reliable that alternative collectors



Dowty have also developed this gas-bearing centrifugal compressor for returning gas samples to the reactor after they have been through the precipitator. It stands about three feet high and is therefore much more compact than the Calder compressors

are no longer very attractive. As with the later designs of valve, pneumatic actuation is employed. The wire store, complete with pneumatic drive, is permanently mounted on a frame so that maintenance is even easier than for Berkeley equipment.

Gas from the precipitators must be returned to the main coolant circuits using a compressor to make up the pressure drops in the system. The density of the high pressure gas makes a centrifugal blower attractive and the use of gas-lubricated bearings overcomes difficulties of sealing and lubrication. Dowty's have now developed a range of compressors of this type which are very much smaller and more compact than those used at Calder.

Private nuclear research on a grand scale

Fission and fusion at Aldermaston

THE RESEARCH LABORATORIES of Associated Electrical Industries Ltd at Aldermaston leapt into world fame last month with the disclosure of their remarkable achievement in obtaining thermonuclear reactions with their SCEPTRE III toroidal discharge machine. This, however, is only one aspect of the work of the laboratories which are unique in this country in being the only private organization to own a reactor—the MERLIN medium-flux research reactor. Through the courtesy of Dr. T. E. Allibone, FRS, the Director of the Laboratories, NUCLEAR POWER recently had an opportunity of seeing some of this work.

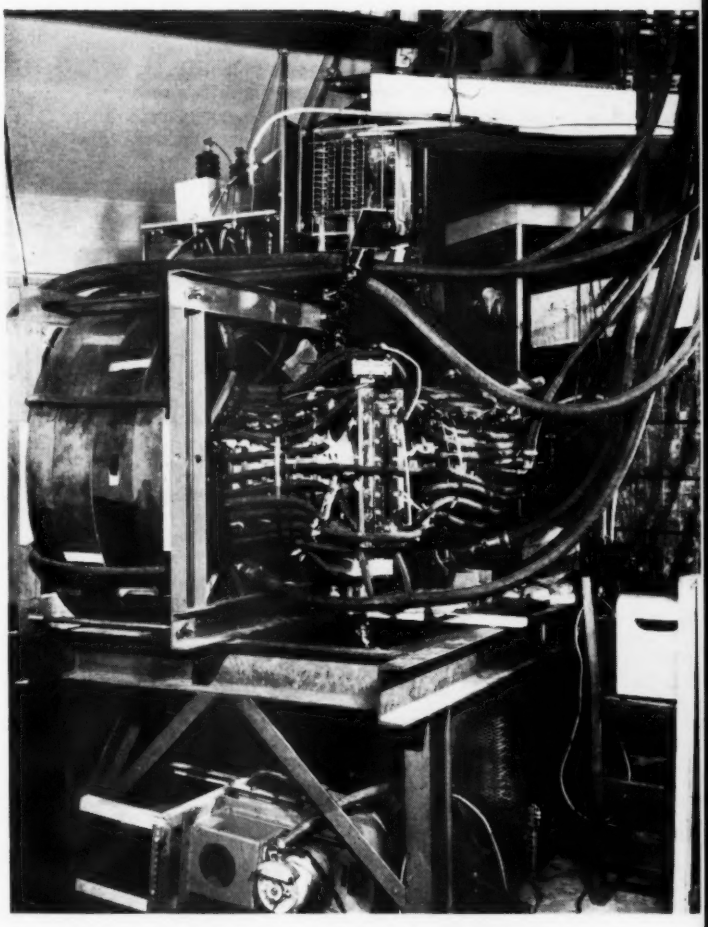
The curtain lifts

Thermonuclear work in AEI had its origins just after the war when Sir George Thomson, then at Imperial College, started working on high temperature gas discharges. In 1951 however, the Government decided to classify the work and it was moved to Aldermaston, where it remained under close secrecy until last month. Between the years 1951 and 1955 a number of small toroidal discharge tubes in glass, porcelain and aluminium were made and tested but the problem of preventing the gas wriggling proved very difficult. In 1956 a much bigger machine was built. This used a 12in bore aluminium torus with a mean diameter of 45 in. and the core weighed four tons. This torus was one of the race-track form i.e. it had a pair of straight sides to ease the problem of photography. It also had a solenoidal winding to give the axial field which, it is now revealed, is the key to plasma stability. Results from this machine were very encouraging and Doppler broadening observations indicated temperatures of a million degrees.

Later, the straight sections were removed and the machine became known as SCEPTRE III (for the record SCEPTRE I was a 2 in./10 in. copper-plated quartz torus and SCEPTRE II a 2 in./18 in. copper torus).

With SCEPTRE III temperatures of from 2·3 to 3·8 million degrees were reached early in January. Study of the applied voltage and discharge current wave forms have shown that at M3°C the gas has a resistivity 100 times that of copper, when carrying 200,000 amperes for about half a millisecond. Neutrons have been observed at all currents above 70,000 amps and the plasma has appeared to be stable. Modifications are now in progress to achieve even higher plasma temperatures. Thermonuclear work at Aldermaston is under the leadership of Dr Alan Ware and comes under the Nuclear Sciences Group directed by Mr. D. R. Chick.

Another section of this Group is the Reactor Section led by Dr Alan Salmon. Their outstanding achievement is the MERLIN reactor. This is in an advanced state of construction in the grounds of Aldermaston Court and is expected to be due for initial trials in the summer although, owing to the big programme of commissioning trials arranged, operation at the full power of 5 MW is not expected before the turn of the year. In designing and building the reactor AEI's object was to combine reasonable economy in capital costs with a range of experimental facilities that would make it of real use in power reactor



The fruit of nearly twelve years of scientific work—seven of them here at Aldermaston—AEI's SCEPTRE III thermonuclear apparatus is surprisingly simple yet temperatures approaching those of Harwell's much bigger ZETA have been achieved with it

The MERLIN 5MW research reactor is housed in this building at Aldermaston Court. A similar one is being built at the nearby Atomic Weapons Research Establishment and a third is on order for Germany

development. Thus while its potentialities are less than those of the Atomic Energy Authority's heavy water high-flux reactors DIDO and PLUTO it is a very much more versatile and powerful tool than the open swimming pool type. In addition to its use by the AEI group the reactor will be made available to universities for research programmes.

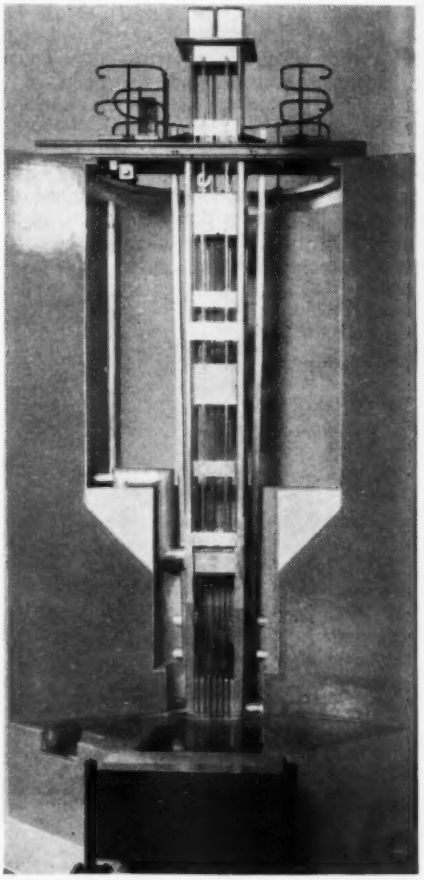
Early in the design stages it was agreed by the AEA that 90 + pct U-235 could be made available and this resulted in a very compact reactor using light water as moderator, coolant and partial shield. It may thus perhaps best be described as a tank-type reactor, the 'tank' being an open cylindrical aluminium vessel surrounded by octagonal concrete shielding. In its upper part it is 11 ft 6 in. in diameter and this narrows to 5 ft 6 in. at the lower end where the core is installed.

The lower part of the tank—that containing the core—is of double-skinned construction, the annulus being filled with a four-inch thickness of lead, water-cooled by embedded pipes, to provide a thermal shield. The outer skin is fitted all over with thermocouples.

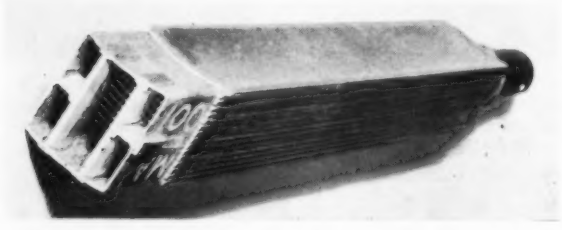
Movable core

The core lattice is fitted in an aluminium box structure which can be hoisted to one of four positions. Reading from top to bottom they are: loading, upper experimental holes, lower experimental holes, safe position. The core assembly is of box-type elements very similar although not identical to those used in some of the AEA's research reactors. Each element has 14 curved Al-clad fuel plates each containing 10 g of U-235. Various lattice arrangements are possible in the 7 × 7 space available. Minimum critical mass is expected to be achieved with about 20 elements but the operational figure is likely to be 25 (3·5kg). Maximum flux figures are expected to be 5×10^{13} thermal, 2×10^{14} epithermal and 3×10^{13} over 1 MeV.

The cruciform-section control elements are of cadmium sheet clad in aluminium and are four in number *viz* one fine control rod (controlling 0·005 reactivity), one coarse rod (0·055) and two safety rods (0·055 each). The coarse rod or one of the safety rods are each invested with slightly more than the maximum built-in reactivity. These control elements are carried on the ends of long rods which extend up to the drive motors which are mounted on the top end of the aluminium core support structure and thus move with it. The fine control rod has a continuously variable speed control but the coarse rod is withdrawn at a constant speed, taking 25 minutes for a complete



A model of MERLIN shows how the entire core assembly can be moved between experimental facilities lying on two horizontal planes. The upper part of the tank provides top shielding. Note the coolant water duct communicating directly with the core basket

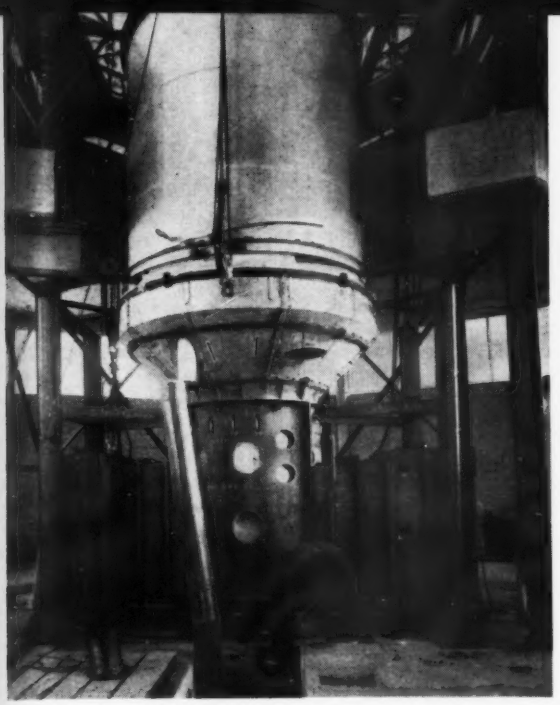


Fuel elements are of the well-tried multi-plate type used on other British research reactors. Normal elements contain 14 plates each containing 10 grams of U235 and two dummy cover plates: special plates contain more dummies so that in effect less than one complete element can be added

operation. The coarse and safety rods are held by magnets which can be de-energized in an emergency. Below outputs of about 1 MW all expected reactivity variations can be handled by the coarse rod: above this power level it will handle equilibrium but not peak poisoning.

An automatic servo system is incorporated in the fine control rod circuit to cover all normal reactivity fluctuations but the amount invested in this rod is such that no conceivable fault in this circuit can put the reactor prompt-critical.

For flux measurements, six boron-coated ion chambers, connected in parallel in pairs, are fitted to the reactor.



When the reactor is complete the entire tank will be surrounded by a monolithic octagonal concrete shield marked by the vertical stanchions rising from the outside ends of the two thermal column shells (right and left). This shield will also be used to support the upper floor through the partly completed concrete beams seen at the top. Meanwhile the floor is held on temporary stanchions

One pair moves with the core structure and is connected with the shut-down amplifier. Another pair—one chamber at each working position—is connected through a linear amplifier to give a reading of reactor power and to provide a signal for the servo system. The third pair are connected with the logarithmic amplifier to feed the period meter. The fission chamber is of course used to give an indication of flux during shut-down or sub-critical conditions. In order to make impossible its omission after work on the core the normal antimony-beryllium neutron source in MERLIN is not just one unit but a small source is attached to each fuel element. A great deal of thought has gone into this reactor and the safety and trip circuits are designed to ensure security under all conceivable conditions of fault. In particular, the maximum possible rates of reactivity addition have been severely limited and the experience of the United States Atomic Energy Commission's experience with BORAX 1 has proved very useful.

As to experimental facilities, MERLIN has the following: in the upper position of the core there are six 6-in. horizontal beam holes, two passing right through the tank near the core. The lower position has two large graphite thermal columns and one 12-in. and three 6-in. horizontal beam holes. In addition there are two vertical tubes, a void in the centre of the core and a shelf near the core on which objects can be placed.

Cooling is provided by circulating demineralized water through the core tank. On leaving the reactor the water passes through a 100-sec delay tank to allow decay of 7·3 sec N-16 before it enters the heat exchangers. These are vertical shell and tube units, secondary water on the shell side coming from a lake in the grounds.

The reactor is contained in a building of simple and functional design extending to about 50 feet above floor level. To keep a strict control on gaseous effluent none of the windows open, ventilation being entirely artificial with filtered intakes and extract. There will be about five air changes an hour. A liquid effluent plant is installed between the reactor building and the nearby lake.

The laboratories also include a critical assembly building in which studies of MERLIN core arrangements are carried out in a water tank of reinforced glass fibre.

Typical of the work being carried out on this assembly is the determination of the effect of a central void in the core, the effect of control rods and the temperature coefficient of reactivity.

In addition to the reactor which AEI are building for their own use, they have orders for two further ones. The first of these is already under construction at the Atomic Weapons Research Establishment, which is also at Aldermaston. The other is for the German provincial government of North Rhine Westphalia. Work has not yet started on this reactor but the site chosen is near Cologne.

PROGRESS IN INDUSTRY

A power reactor simulator

English Electric's new model

DESIGNED mainly for training and familiarization purposes, a simple reactor simulator has recently been produced for the commercial market by English Electric's Control and Electronics Department at Kidsgrove from a basic design, developed at the company's Atomic Power Division's headquarters at Whetstone.

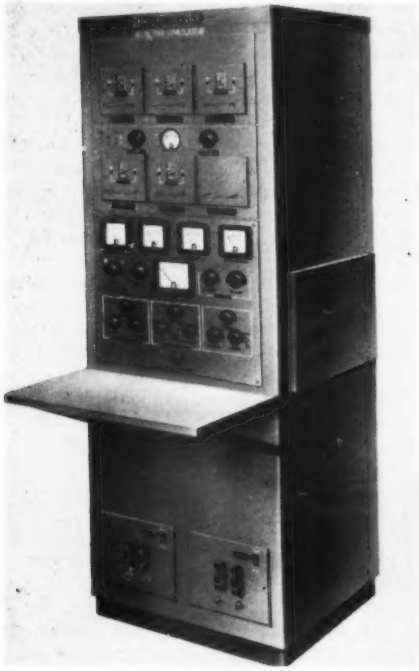
Basically the simulator is a simple analogue machine capable of solving certain fundamental equations representing the actions of a reactor under operating conditions. It also incorporates means for controlling or varying these actions so that operators can acquire the 'feel' of a real control system.

The purpose of this simulator is functional and consequently it is housed in an upright steel-framed cubicle 6 ft high by 2 ft wide by 2 ft deep. This is considered to be economically more acceptable than a console-type control desk. The cubicle is sub-divided into three separate sections the top section comprising five computing amplifier units and a servo multiplier-amplifier unit—all built on withdrawable-type chassis. Only four of the computing amplifier units are normally in operation, the fifth being a spare which can be connected in circuit as and when required by means of input and output jacks situated on the main front panel of this section.

All connexions to the computing units are made through plug and socket arrangements which are mated when the

chassis unit is inserted in its recess on the main cubicle. Arrangements have been made by a properly terminated lead for either of these units to be maintained or tested outside the cubicle under operating conditions.

Automatic drift correction has not been incorporated in the computing amplifier units but provision has been made for this adjustment to be carried out manually. A set-zero switch and associated screwdriver-adjusted poten-



The simulator is completely self-contained in a simple upright cabinet. On it may be performed all operational actions likely to be encountered with real reactors

tiometers are mounted on the front panel of each amplifier unit and the amplifier outputs can be monitored by a meter.

Many variables

The control system is mounted in the centre section of the cubicle and control facilities and indicating meters are all mounted on the face panel associated with this section. These facilities include selector switches for setting up various conditions on:

a. Control-rod movement
   fine; coarse stepped; variable constant velocity
b. Neutron source.
c. Fuel selection.
d. K step.
e. Built-in reactivity.
f. Trips for power level and period.
g. Mass flow selection.
h. δ K scaling.
i. Gas inlet temperature.

together with indicating meters showing:

i Excess reactivity.
ii Control-rod position.
iii Reactor period.
iv Nuclear power.
v Fuel surface temperature.

If it is required to simulate different reactor arrangements, the computing components are readily accessible at the rear of the amplifier panels.

A table-top is fitted immediately below the control panel, at approximately desk top height, for the operator's use. A second table-top at the same level, is fitted to the side of the cubicle to support a recorder when this is required. As the use of a recorder may be intermittent this table is made to fold to the side of the cubicle when not in use.

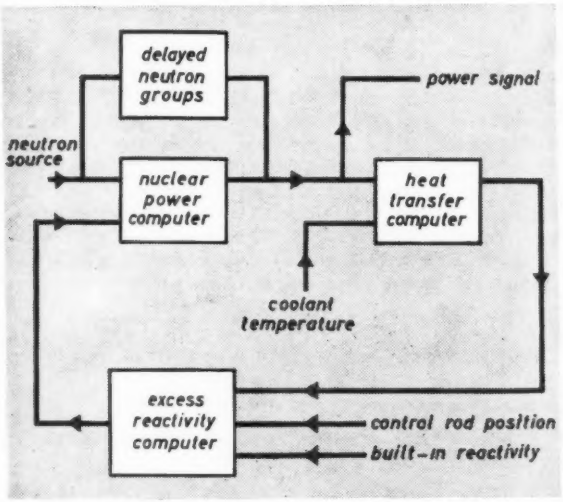
The lower section of the cubicle contains the power units which provide h.t. and l.t. supplies to the computing amplifier units and are fed from single-phase 50 c/s a.c. mains.

The reactor equations are simulated by three basic computer elements, The Nuclear Power Computer, Heat Transfer Computer and the Excess Reactivity Computer. These elements are connected in a closed-loop circuit which has provision for certain signals to be injected at required points.

Closed loop

Signals representing Built in Reactivity, Fuel Temperature and Control Rod Position are fed into the Excess Reactivity Computer which, from this information, produces the δ K signal. The position of the control rod may be varied transiently, or by a fine manual control, or may be set to move at a required velocity.

The δ K signal together with a Neutron Source Signal, set at the control panel, constitutes the input information to the Nuclear Power Computer. This unit comprises a d.c. amplifier which, when fed with this information, simu-



The block schematic of the simulator shows how the three computers—nuclear power, heat transfer and excess reactivity—are linked

lates the appropriate transfer function together with the delayed neutron effects. Delayed neutron networks, appropriate to the fuels selected are set by the Select Fuel potentiometers on the control panel.

The loop is closed by feeding the Nuclear Power signal from the output of the Nuclear Power Computer to the input of the Heat Transfer Computer, together with a signal representing the coolant input temperature.

A significant feature of this unit is the incorporation of a 'Mass Flow' control which may be used to illustrate how the power of a reactor can be controlled by coolant mass flow.

Trip circuits have been incorporated into the circuit and can be set to simulate shutdown at a preset level or at some defined rate of increase of the power level.

At one of the French uranium mines—Lachaux in the Massif Central—ore is brought up by this pithead gear and transported by aerial ropeway to the concentration plant

Metropolitan France, with her overseas territories, is a rich source of uranium. Here is how the metal is produced at Le Bouchet plant

Uranium ore reduction

the French process

MAURICE MOYAL, PhD

LITERALLY HUNDREDS of uranium ore deposits have been discovered all over France, and half of the country's overall area of 212,659 square miles, consisting of Hercynian granitic terrains, is potentially uranium-bearing: Madagascar, the French-controlled island in the Indian Ocean, is the largest depository of uranothorianite ore in the world.

While the metal contents of the ores at Cisson are far higher than the richest deposit in the US, there are also tremendous reserves of low-grade ores. The Commissariat à l'Energie Atomique has therefore been paying great attention to the separation of uranium, devising some more economical and better chemical and physical treatment processes. Earlier processes required a good deal of costly liquid reagents. As there are huge quantities of low-grade ores the world over, it is therefore vital to find ways of using less of these. The novel French processes, achieving just this, are thus bound to have a decisive bearing on both the quantity and price of uranium, and hence on the rate of world development of atomic energy.

Three-stage treatment

In the French method low grade ores, containing less than 0·2 pct uranium, are physically or chemically treated in plants on the spot. The resulting concentrates and high grade ores, containing from 0·2 to 1 pct and sometimes an even higher percentage of uranium, are shipped to the Le Bouchet plant, built in 1946 at Vert-le-Petit on the outskirts of Paris.

In this plant, covering over eighteen acres, the ores are dried in furnaces, ground, and then pulped with water. Various processes are used that will allow recovery of up to 97 pct of uranium. During extraction into pure uranium mattes, the ores undergo three stages of treatment: the concentrate is turned into sodium uranate; the uranate is processed into pure oxide; the oxide is reduced to metal. Treatment varies according to the origin, type and degree of concentration of the ores. Allowing for some measure of variation in each particular case, the following flow sheet is applied to all ores and concentrates.

The pregnant solution is first decanted through stainless steel Dorr Oliver thickeners, and the waste material thoroughly washed through press filters. The recovery of such impurities as lead, titanium and zirconium is under study. The solution is treated by sodium carbonate, which precipitates such metals as iron, manganese, lead, etc, as hydroxides and phosphates, leaving the uranium solution as uranyl carbonate. This in turn is treated by a boiling solution of caustic soda, which precipitates the sodium uranate.

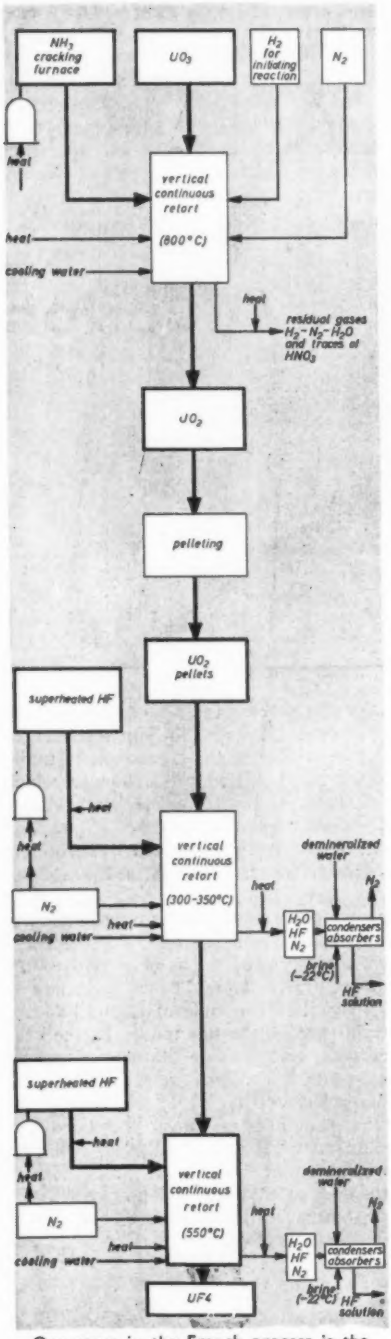
Besides employing the nitric acid process now in general use, the Le Bouchet plant is also equipped for sulphuric acid treatment. A satisfactory process has been evolved for treating flotation concentrates containing a considerable amount of organic reagents. With ores of high lead content, the treatment will precipitate this metal. In the case of complex ores, the plant combines the features of several processes and thus avoids the difficulties attendant upon treating each ore separately.

It is noteworthy that radium is no longer recovered, but in the course of treatment great care is taken to render it non-soluble by the addition of barium carbonate and, if need be, of sulphate ions so that the radium-barium sulphate will remain insoluble in the waste material. This helps to prevent the pollution of the rivers into which this waste is pumped.

Extraction as nitrate

The purification of the sodium uranate obtained from various types of ores is based on the solubility of uranyl nitrate in organic solvents. For this extraction ether has been abandoned as too dangerous, while the use of hexane has been also discontinued because this had to be in conjunction with ammonium nitrate. Tributyl-phosphate has become the accepted medium. Though rather expensive it is exceptionally long-lived and is capable of almost total recovery.

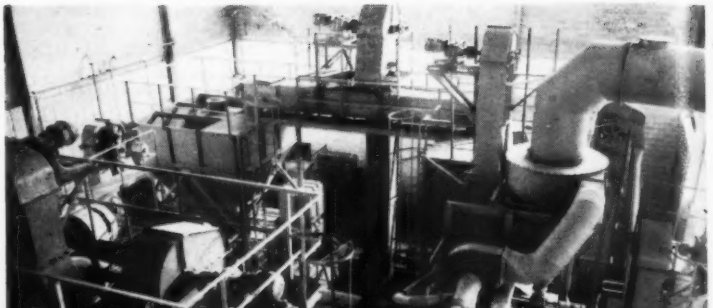
Extraction is accomplished in counter-current stream in two 15ft high columns fitted with Rashig rings. Distilled water percolates down the columns and the nitrates of all metals remain in aqueous solution, while the solvent containing the uranyl nitrate is emitted at the top. In practice



One stage in the French process is the reduction by ammonia of UO_3 to UO_2 and its subsequent fluorination to UF_4

only a very limited amount of uranium stays at the bottom of the columns, and even this can be recovered. After subsequent purification in another column, nearly all impurities have been eliminated, but the uranium is still in the form of a diluted nitrate solution. To transform this into the solid state, precipitation of uranium in the form of UO_4 has been chosen because it has the advantage of eliminating further impurities.

Solidification is accomplished in heated and continuously



In this part of Le Bouchet factory concentrates are dried and ground prior to extraction of impurities by solvent extraction with tributylphosphate

agitated vats by the addition of oxygenated water and ammonia, the latter serving to stabilize the pH value of the solution under precipitation. After filtration and washing of the UO_4, there still remain some traces of iron, manganese, silica and other impurities in the oxide, in the following proportions in ppm: Fe 1·5, Cr 0·4, Cu 0·3, Mo 0·3, Ni 0·2.

Oxide reduced by ammonia

Uranium mattes have been produced on an industrial scale at the Le Bouchet plant since 1950 and while the purity of the metal has not been appreciably increased, the process has been greatly improved.

The following are the stages in the production of the metal from UO_4:

1. heating at about 400 deg C converts UO_4 into UO_3
2. UO_3 is converted by ammonia gas into UO_2 in a vertical continuous retort
3. UO_2 is pelleted
4. the UO_2 pellets are converted by hydrofluoric acid into uranium tetrafluoride in a vertical continuous retort
5. the tetrafluoride is reduced by adding shavings of pure calcium to the melted uranium and subsequently cooling it into mattes.

At first a stream of hydrogen at about 750 deg C in a vertical furnace was used to reduce UO_3. To give greater control of the reaction, nitrogen had to be added and subsequently cracked ammonia was used. Currently, however, the reducing agent is a stream of ammonia, the gas being dissociated on contact with uranium oxide. The oxygen released acts as a scavenger and improves the efficiency of the process. Thus a 3ft high vertical oven and a 3 ft cooler are sufficient to reduce one ton of oxide per 24 hours.

The UO_4-UO_3 reduction furnaces function automatically: the gas volumes are measured and controlled by rotameters, and the final product, which is slightly reactive to oxygen, is handled in an inert atmosphere.

Fluorination and dehydration

For the last five years the method of fluorination used at the Le Bouchet plant has been to transform UO_2 by attacking it with a 40 pct solution of pure HF. The reaction takes place in an ebonite vat equipped with a mixer

made of the same material, the volume of HF being about 25 pct in excess of the theoretical amount. To prevent the temperature of the mixture from rising above 60 deg C, the oxide is introduced gradually and is constantly stirred. The mix is put through an ebonite filter fitted with polyvinyl chloride cloth. It is washed in a very dilute solution of HF and finally in methanol.

Drying of uranium tetrafluoride calls for the utmost care as moisture would result in a noticeable reduction in the quantity and quality of the metal. On the other hand, too lengthy drying at too high a temperature in air would result in hydrolysis and marked oxidization of the metal. After being suspended for a period in an air stream, the cake, still containing 50 pct of water, is dried at 200 deg C in a furnace lined with lead. Still containing 2-3 pct of water, it is then passed through a crusher which, to avoid the addition of new impurities at this stage, has been surfaced with uranium metal. It is dried the second time at 500 deg C in hydrogen in a vertical copper furnace. The moisture content is now only about 0·3 pct, the corresponding loss in weight having been brought about in vacuo at 150 deg C. The product is free from uranium oxide and contains a very small amount of uranium hexafluoride.

Trayless furnace used

The anhydrous fluorination plant currently in use at Le Bouchet resembles that used for the UO_3/UO_2 reduction process. This process has been finally adopted after a few unsuccessful experiments, e.g. fluidization, furnace with trays, etc. The use of the current trayless furnace has been made possible by the prior briquetting of the uranium oxide into pellets, thus facilitating automatic control. The furnace apparatus and secondary circuits have been made out of special materials such as Monel, copper, graphite, and synthetic resins, all of which are corrosion-resistant. The problems of corrosion vary from point to point.

The apparatus consists of a vertical tube, slightly widened at the base, set in an electric furnace which is used only to prime the reaction. Once started, the exothermic reaction generates sufficient heat to maintain the temperature which is held at 450-500 deg C. The gas used may contain a certain amount of nitrogen, and even hydrogen, and invariably some hydrofluoric acid, at least 20 pct in excess of the theoretical amount. The resulting tetrafluoride may contain from 1 to 1·2 pct of oxygen without interfering with the next operation.

One matte a day produced

The crucibles are made of stainless steel and lined with calcium fluoride to avoid contamination of the metal. Crucibles of pure calcium fluoride obtained from purified natural fluoride are capable of holding molten uranium without deformation.

At the start of the reaction, excess calcium is allowed to escape through an aperture. After the reaction, which lasts only for a second or two, the receiver is closed again and the matte is cooled in an argon atmosphere by a water-cooled jacket. The matte, topped by a mass of melted uranium tetrafluoride, is extracted from the crucible by a special apparatus. Each furnace is capable of producing one matte a day, which may weigh anything up to 220 lb.

Pure calcium needed

To turn out high-grade uranium metal, it was imperative for the materials, the reagents and the products themselves to introduce into the mattes an irreducible amount of impurities in the course of the latter stages of processing. This has set a number of secondary technical problems, which have been resolved in cooperation with private industry. For instance, the Société Metallurgique du Planet, specializing in the fabrication of light metals, was entrusted with the task of evolving a new process for turning out nuclearly pure, twice distilled calcium.

At the start, the classical aluminothermy process was changed to:

$$3CaO + 2Al \longrightarrow 3Ca + Al_2O_3$$

This is performed *in vacuo* at about 1300 deg C in refractory cement ovens, the load being heated by direct irradiation from graphite resistors.

Raw calcium is refined by sublimation in a retort in an almost complete vacuum. The result is a product absolutely pure from the nuclear viewpoint. The one impurity in significant amount (0·1 pct) is magnesium, and as it plays the same role as calcium in the reduction of uranium tetrafluoride, elimination is not imperative. All other impurities put together amount to about 30 ppm. Calcium mattes come in the shape of flat cakes, weighing some 30 lb apiece and are pared into shavings for use.

High purity product

Another secondary problem was the fabrication of pure calcium fluoride crucibles. Such crucibles are turned out

The final reduction of the pure uranium tetrafluoride to metal is done with calcium in calcium-fluoride-lined crucibles

at the Le Bouchet plant. To enable them to receive molten uranium without deformation their calcium contains only 0–0·5 pct impurities, mainly Fe and SiO.

The result of such painstaking care is responsible for the fact that uranium produced in France now has a 99.999 pct pure metal content. The fact that a charge of only 20 tons of this uranium was needed to make the G1 reactor at Marcoule divergent (NUCLEAR POWER, *September 1957, p 356*), bears witness to the high quality of French uranium and graphite. In July 1956, G1 started to generate 40 MW for the nation's grid, to be followed in 1958 by G2 and G3. But the primary role of all three piles at Marcoule is to manufacture plutonium.

By 1959, the first purely atomic electricity plant will be generating 70 MW, to be followed next year by a whole series of similar nuclear plants in the valley of the Loire river, in central France. These will be generating enough electric power to provide for a greatly increased industrial consumption of power which is expected to double within less than eight years.

Cross Section by GRACCHUS

THE TIMING of the ZETA announcement last month struck me as rather odd: it seemed to me either too late or too early—I'm not sure which. According to the official statement these very high temperatures were first reached on August 30 and if it hadn't been for international politics the announcement should have been made during the next few days. Admittedly there was doubt about the origin of the observed neutrons but the point is that when the announcement finally was made on January 24 the uncertainty still remained. Once the opportunity had passed for making an early announcement surely it would have been better to have waited until the neutrons could have been pronounced legitimate?

THE PENALTIES of fame are indeed severe and I rather felt for ZETA-man R. D. Pease on his elevation by Miss Anne Edwards in her *Daily Express* column to the finals of her Most Attractive Man in the World Contest ('the youngest and certainly the handsomest of the Harwell team'). Pease ('remote boffin look') certainly found himself in strange company—Nikita Krushchev ('masterful'), the Aga Khan ('fun'), the Duke of Bedford ('democratic') and John Neville ('brooding'). This fulsome reward after years of toil on plasmas must have been rather hard to live with for a few days but I've no doubt it will help him in his career. The outright winner in Miss Edward's competition?—oh yes, the Duke of Edinburgh ('knock-out').

ONE OF THE PROBLEMS of the fission product disposal boys at Windscale is the fact that seaweed is a national dish in Wales. I was at the recent BNEC symposium—reported this month in *Institutions*—when Saddington, deputy head of Windscale R & D, talked about this. Every day millions of gallons of low-activity effluent are pumped into the sea off the Cumberland coast where it is diluted down to the permissible level. However, silt and seaweed have the property of reconcentrating it. And at certain places on these coasts, onshore seaweed is collected by the Welsh, cooked, and served up as a concoction called laver bread. I remember a holiday I had some time ago with a very Welsh family in Llanelly where the virtues of this delicacy were extolled to the point where I just had to try some. It was served up with my morning bacon and proved to be a particularly unappetizing mess, looking rather like strained spinach.

Mr Saddington told me afterwards that this eating habit limits the quantity of effluent which can be put out to sea by a factor as high as five. Evidently the Authority did consider trying to discourage the custom but decided in the end that it would be easier to improve the efficiency of the concentration process.

THE PEACEFUL uses of Atomic Energy multiply daily and I was fascinated to learn of a completely new application in a letter I have just received from a correspondent in the Swedish Atomic Energy Company.

'In Sweden there has been some suspicion during the last 380 years that the late King Erik XIV died by poisoning. To settle this question the tomb was recently opened and scientists undertook a careful investigation of the Royal Mummy. Some specimens of the tissue have been irradiated in the experimental reactor R1, and we are now in a position to disclose some interesting results. It seems that King Erik XIV undergoes the reaction $E^{XIV}(n,\gamma)E^{XV}$ so that a new compound King Erik XV is formed.

This artificial king is unstable and decays by emission of some betas and soft gammas to K^{XV}, King Karl XV. The decay scheme is still missing but the half-life can be estimated from historical evidence: King Erik XIV died in 1577 while King Karl XV mounted the throne in 1859. The instability of E^{XV} verifies the fact that King Erik XV has never been found abundant in nature. There is some confusion in the terminology though, as K^{XV} hardly can be considered a daughter product.

As the material is still just a little bit calssified (*calcified?—Ed.*), would you please withhold my identity.'

This is obviously just the thing for solving the great Shakespeare mystery and a good starting point might be for the theoretical people to work out a possible parent element for Bacon before expensive pile irradiations are started.

QUITE A LOT has happened to atomic energy in the United States since those carefree days in Geneva 1955 when the casual visitor to the exhibitions might have imagined that that great country was already dotted with nuclear plants. Since then the picture has been put into perspective but nowhere better I feel than in Oliver Townsend's address to the American Assembly at Columbia University last October. I've just been reading the proceedings and I thought Townsend's conclusions—he is Secretary of the Atomic Industrial Forum and was a personal assistant to Gordon Dean when he was AEC chairman—very succint. I quote—

'1 Although the United States today is unquestionably in a period of rising costs and unanticipated technical difficulties in the field of atomic power, there still seems to be no serious diminution of real, hard-core industrial interest.

2 The industrial base of the United States' atomic power programme is really much smaller than most people seem to think it is. Actually, there are less than half a dozen companies deeply involved in the atomic power reactor business in the United States. Recently this base has begun to be broadened a bit, but it is still narrow, and it is still too early to tell how many of the newcomers will be able to stick it.

3 There would seem to be no question but that the United States atomic power programme has never been pursued, except possibly in its submarine phases, with the sense of urgency or degree of success with which the bomb project was pursued during World War II. This, however, is not very surprising when one remembers that bombs and weapons have always had to have top priority in the United States, and when one remembers too that the United States really has no pressing domestic need for atomic power.'

In spite of these facts however Townsend notes that the Euratom Wise Men found America 'with the most complete nuclear foundation in the world.'

APROPOS of my note last month on the 'Risley acrobats,' the Editor has appealed to me to explain this as he's been bombarded with enquiries. This I can now do—after some considerable research.They are the chaps who lie on little sort of velvet-covered beds—they're actually called 'trinkas' in the trade—and juggle things with their feet. This type of act, I find, originated with a 'Professor' Risley in the 1840's.

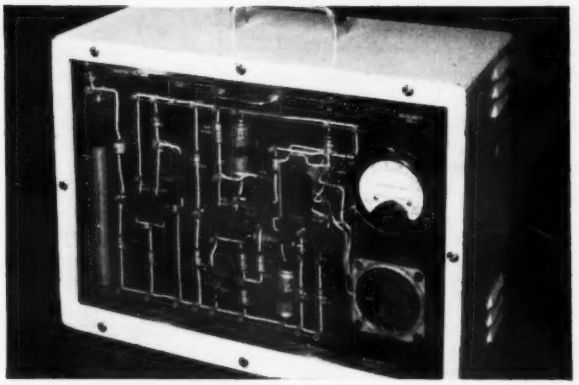


Fig 1 Designed for education and training, this gamma radiation monitor has a transparent front panel engraved with the counting circuit and waveforms for easy explanation

W. KIRYLUK, AMBritIRE

Chief engineer, nucleonic instrumentation laboratory Burndept Ltd

A DEMONSTRATION RADIATION MONITOR

SOME TIME AGO a radiation monitor was described (*1*) which has been produced in quantity for use at Harwell. In the light of recently revealed shortages (*2*) of fully trained radiation health inspectors and experts, it is felt that it may be of general interest to reconsider its use in a wider field.

Monitor, type 1187A, has been designed as a demonstration model for educational, services training and civil defence authorities, in collaboration with Harwell. This geiger counter radiation monitor by Burndept Ltd can be used for innumerable instructional experiments to illustrate the operation of gamma radiation monitors. It is self-contained, mains operated and complete with the usual controls; aural and visual indication of counting rate is also provided. The monitor has a Perspex front panel (fig 1) which is engraved with the multi-coloured counting circuit and the actual components are mounted behind the panel. The engraved circuit is illuminated by edge lighting of the panel and additional internal lighting can be used for the components. The various circuit waveforms are also shown on the Perspex. Robust in construction, the monitor is contained in a portable cabinet 15 in. by 11 in. by 7 in. and weighs approximately 27 lb.

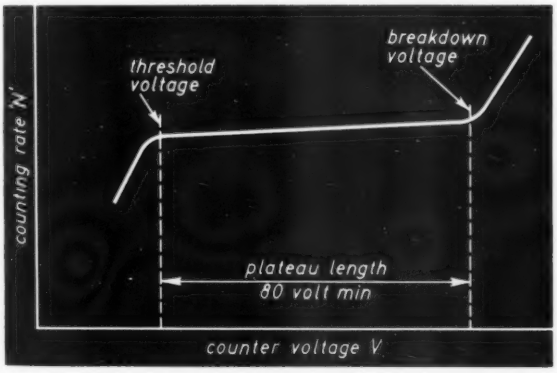


Fig 2 Typical geiger counter characteristic has voltage plateau. Tube is operated in the middle of this region

The power unit is built on a separate chassis which slides into the main box and is accessible by removal of the rear cover. A special compartment for the mains lead is provided at the bottom of the carrying case. The convenient presentation of the monitor makes explanantion of the action of the instrument possible even to non-technical personnel.

Halogen quenched tube

The geiger counter, CV 2173 (20th Century Electronics Ltd, type G10H) used in this monitor, is the halogen quenched type employing a gas mixture of neon, bromine and argon. The addition of argon helps to bring down the striking voltage to 375 volts from the usual 1100 volts typical for organic quenched tubes.

In principle, operation of such a tube relies on the fact that the gamma radiation knocks out an electron from the cathode. This electron causes an avalanche effect whereby the gas momentarily ionizes, producing a negative going voltage pulse across the load resistance R_1. If the wall of the tube is sufficiently thin, beta particles can also enter the sensitive volume and will produce ionization directly i.e. without first reacting on the cathode. Detection efficiencies are in the region of 1 pct for gamma radiation and about 98 pct for counting beta particles. In fact all beta particles which get inside the tube are counted.

A typical characteristic of a geiger counter is shown in fig 2. It can be seen that a pronounced plateau occurs between two limits known as threshold and breakdown voltages. Below a certain e.h.t. voltage applied to the counter the pulses produced by the tube are small and varying in height. Between the two critical limits the ionization pulses caused by the gamma radiations are constant in amplitude, and when the e.h.t. voltage is increased still further a complete breakdown of the gas occurs and spurious pulses are generated. The length of the plateau is equivalent to about 80 volts and the tube is operated in the middle of this region, achieved by making the e.h.t. supply adjustable.

Standard circuit

The circuit (fig 3) employed in this monitor follows standard practice, and it has been fully described elsewhere (*1*). The circuit diagram is included here for the sake of completeness. It is worth mentioning that all nuclear detectors are insensitive for a period following the detection of a particle; this paralysis time depends upon the type of detector and circuit used. In this instrument the circuit complexity has been avoided for the sake of clarity, and although the paralysis time of this monitor is

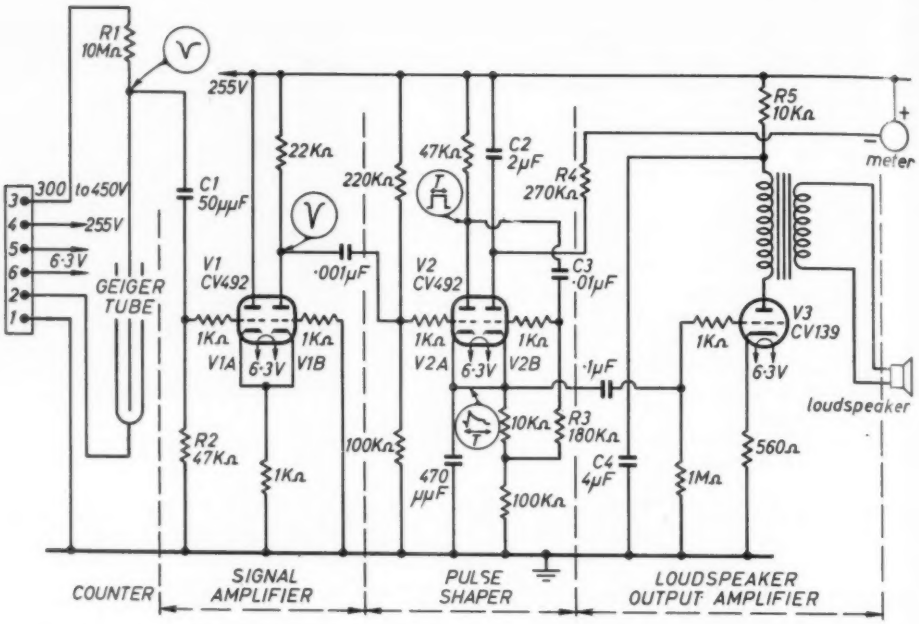


Fig 3 Circuit diagram, shown in outline on the instrument's front panel, follows standard practice; not shown here, the power supply is also of conventional design. Note the various pulse shapes at circuit junctions

slightly in excess of 5 milliseconds it can be considered negligible for demonstration purposes.

The power supply (not shown in fig 3) is of conventional design. The h.t. is stabilized by means of two neons connected in series, one 150 and the other a 105 volt thus giving a nominal 255-volt supply to energize the valves V1 to V3. The e.h.t. is stabilized by means of a shunt valve which also reduces the hum on this line. The actual e.h.t. voltage can be pre-set between 300 and 450 volts and this enables accurate adjustment of the required voltage to the middle of the plateau range, which may vary from counter to counter. The stability is such that a 40-volt change in the mains input causes only a 1 pct change in the e.h.t. supply. To prevent any damage to the counter due to switching-on surges, a thermal delay switch has been incorporated which retards the application of e.h.t. to the counter tube by about 1 minute.

Correction of meter reading

From the earlier description it can be seen that there is a finite delay in operation of the monitor which is determined by the paralysis of the counting circuit and fluctuations in the meter reading caused by the time constant of the meter components. One of the factors contributing to the paralysis of the counting circuit is the recovery time of the univibrator V2 which, in turn, is determined by the time constant of C3 and R3, i.e. while the univibrator is reverting to its original state after it has been triggered, any pulses which may arrive at that time are ignored.

The paralysis time of this monitor is in the region of 5 milliseconds and the meter reading can be corrected by using the formula:

$$N_0 = N/(1 - NT)$$ where N_0 = true counting rate in counts per second
N = apparent counting rate as shown on the meter in counts per second
T = paralysis time of the instrument in seconds

Thus, if the monitor reads 50 counts per second, in actual fact the true counting rate is more like 66·7 counts per second. In actual practice a much shorter paralysis time could be achieved but in this case it was felt that the additional expense was not justified.

Fluctuations of the meter pointer are caused by the random nature of radiations emitted by radioactive sources (*3* and *4*). If n is the number of arriving counts per second and T_1 is the time constant of the meter circuit, then possible deviation from the mean pointer position can be calculated from the following formula:

$$\text{r.m.s fluctuation} = 1/\sqrt{(2nT_1)} \times 100 \text{ pct counts per second of meter reading}$$

Thus, if the counting rate is 50 counts per second and in this monitor T_1 is approximately 1 second, the r.m.s. fluctuation can be 5 counts per second.

Use of radioactive sources

Subject to the already mentioned error corrections, this monitor, primarily designed for circuit demonstration purposes in a lecture room, can also be used with ease for actual practical radiation measurements. Thus one of the basic experiments is to calculate a dose rate from a gamma emitting source, then to measure it, apply suitable corrections, and compare the result with the calculations.

An experiment of great value in training radiological protection teams is to verify the calculated attenuation of gamma rays by such shielding materials as lead, concrete, brick and steel. The attenuation effectiveness of these materials is quickly appreciated by comparing the monitor readings with the source shielded and unshielded. The monitor can be used also for investigations of scattering of gamma radiation, determination of half value thickness for lead to gamma photons, estimation of the energy of radiation, and measurements of half lives of short lived isotopes.

Acknowledgments

The author wishes to thank Mr K. E. G. Perry of AERE, Harwell, who is the design authority of the monitor, and the directors of Burndept Ltd for their permission to publish this paper. Thanks are also expressed to Mr R. D. Phillips of 20th Century Electronics Ltd for his advice concerning halogen quenched tubes.

References

1. Perry, K. E. G., and Goulding, F. S. 'Radiation monitor for demonstration purposes' *Journal of Scientific Instruments*, 1952 *29* (8) August, p. 243-245.
2. *Report on the Organization for Control of Health and Safety in the UKAEA*. HMSO, Jan 1958. Cmnd 342.
3. Elmore, W. C., 'A counting-rate meter' *Nucleonics* 1948 (April) p. 43.
4. Cooke-Yarborough and Pulsford 'A counting-rate meter of high accuracy' *Proc IEE* 1951 *98* (Part 2).

Reactor physics

Physik und Technik der Atomreaktoren Ferdinand Cap. Vienna 1957: Springer-Verlag. 487 pp. Price 109s

All books containing accounts of elementary reactor theory must bear a certain similarity to each other and this one is no exception. Well though it deals with its subject it cannot be said to be better in any way than English texts on the same subject. Why is it also that so many books dealing with the general theory of nuclear reactors try and cover so many different aspects of their subject? Again, this volume is no exception. It is essentially a book on reactor theory, so why introduce such subjects as medical uses of radioisotopes? However, as this particular book owes its origin to a lecture course given at the University of Innsbruck perhaps it is a justifiable procedure to write what is essentially a course textbook.

The first chapter discusses the necessary nuclear physics for the reader to understand the workings of a nuclear reactor and this is followed by elementary slowing-down and diffusion theory of neutrons, including a brief introduction to neutron transport theory. The theory of homogeneous reactors is outlined and this also includes the effect of reflectors and the time-dependent behaviour of a reactor consequent upon a change in its multiplication constant. Heterogeneous reactors are discussed next with particular reference to the calculation of the multiplication constant, the buckling and the temperature coefficient. Perturbation theory is outlined and the effect of control rods calculated. A separate chapter deals with engineering problems of reactors. Fuel, canning materials, moderators and coolants are considered in addition to the problem of heat removal from a reactor. In addition, reactor shielding is also discussed. The consequences of running a reactor are shown including the effects of fission product poisons and the problem of reactor control. A chapter is devoted to a discussion of the different types of reactor with descriptions of particular reactors and finally the use of reactors for specific purposes, such as research and in medicine is considered.

With the reservations given above this is an excellent book containing a great deal of detailed information. It has problems at the end of each section and an enormous number of references. Finally it has one novel feature in that the index is in English as well as German.

J. F. Hill

Metals at high temperature

Behaviour of Metals at Elevated Temperatures London 1957: Iliffe. 122 pp. Price 21s

The full texts of the four lectures constituting the tenth Refresher Course of the Institution of Metallurgists has now been reprinted in book form. The lectures, each by an expert, set out to deal with properties to be considered in designing a component to withstand mechanical and thermal stresses and the chemical attack of its environment.

The first lecture deals briefly with stability of structure and physical properties, with fatigue and with chemical attack, at length with creep and with stresses due to temperature gradients and ends with a note on methods of developing high temperature alloys.

The second lecture which is concerned with the effect of a useful introduction to this subject, and his book should appeal to modern students of agriculture who are the farmers of tomorrow.

ciency. Alloys of aluminium, magnesium, titanium and iron are each considered and compared.

The third lecture on non-ferrous high temperature materials is concerned with the properties of materials containing less than 50 pct iron at temperatures above 500°C. Brief consideration of the platinum group metals, molybdenum chromium and titanium based alloys and alloys chosen for high oxidation resistance is followed by a more exhaustive treatment of the Nimonic series of alloys and their properties.

The final lecture deals with steels almost exclusively from the point of view of creep and methods of reducing creep by solution and precipitation hardening.

While the four lectures are individually authoritative they do not constitute a coherent unit in content or approach to the subject. A preoccupation with creep data has led to partial or complete exclusion of theory and of other topics of importance. For example omission of discussion of the formation at high temperatures of structures such as σ-phase, the influence of cycling temperature and phase transformations or corrosion resistance to high temperature water or steam will decrease the value of the book particularly to the nuclear engineer.

The data and references given are good but not sufficient to form a major source of information and it seems a pity that the opportunity has been missed for a more comprehensive presentation of the current ideas on designing materials for high temperature applications and of the theories of the mechanisms by which the properties are achieved. As an introduction to some of the problems of metals at high temperatures the book will be valuable, but it seems to fall short of what could have been achieved in a revision course.

J. S. Llewelyn-Leach

The problem of growing more

Atomic Energy in Agriculture William E. Dick. London 1957: Butterworths Scientific Publications. 150 pp. Price 15s

Many fields of scientific research to which the science of nuclear energy can be applied are becoming better known to the general public; one such is the use of nuclear radiation in agriculture. As this author points out, the need for more food for the human race (one dare not say 'enough') is likely to remain a global problem, because of the general increase in population; and this problem is one which it is hoped atomic radiation may help to solve.

Most of Mr. Dick's material is drawn from Geneva papers; his aim is to provide background information on the main lines of research in this field, so that the general scientific reader may more easily understand the new results which are constantly being published.

Mr. Dick himself points out that it is pure curiosity, the desire to add to basic scientific knowledge, that prompts most scientists to tackle the very involved problems of photosynthesis, and interesting as his descriptions of work with radioactive tracers in this field are, they are too far removed from 'agriculture', even if it be regarded as a science, to have much value for the general reader. The use of tracers to determine mineral deficiencies and fertilizer needs is of great general interest. And so, in a more specialized sense, is the work being done with tracer elements in forestry. Research on plant mutations, insect control and food preservation by irradiation are of immediate interest and importance both to the agricultural student and the general reader.

In general Mr Dick has succeeded in his object of providing a useful introduction to this subject, and his book should appeal to modern students of agriculture who are the farmers of tomorrow.

D. S. Beard

Plastics in nuclear research

The Mendip Chemical Engineering Co Ltd provided the 'resilon' window tanks which were used to hold the shielding windows in Harwell's new high activity building described elsewhere in this issue. The company has been interested for some time in the uses of reinforced resins in nuclear engineering, and this latest application highlights some of the important advances made in this field. Another recent use is for the tanks holding the moderator in the sub-critical reactor at AEI, Aldermaston.

General interest was first aroused several years ago after certain grades of Mendip Chemical materials had been successfully tested at Harwell in BEPO. It was found that they were not affected by exposure to pile radiation in trials lasting more than 40 h and tests run concurrently established their resistance to the reagents commonly employed as coolants, moderators or decontaminators. Following these encouraging results 'resilon' was used for the central sump tanks at Harwell for which a number of materials had been tried without success. The unit has now been working satisfactorily for over two years.

Another important advantage held by reinforced resins is that very complicated pieces of equipment can be produced in one piece without further welding or fabrication. This points to their use for dry boxes to contain active materials while various operations are carried out manually and prototypes have been constructed by Mendip Chemical with promising results.

It has been found that neutron absorbing properties are good and can be improved by using materials having high hydrogen content in place of the usual inert fillers. In this manner a shielding material of some interest to the production factories is being developed. Engineers concerned with the construction of neutron flight tubes have become interested as reinforced resin tubes would have the attraction of being light in weight and non-corrodible while strong enough to permit the medium vacuum conditions required. Mendip Chemical has constructed prototype tubes and these are being evaluated.

Windowless factory

The new transistor factory built at Swindon for Semi-Conductors Ltd by Richard Costain (see *Companies* November) has now been completed. It is entirely windowless and idea is to reduce dust in the factory to an absolute minimum. On entry each day the employees will set cleaning plant in motion—switched on by opening the door—and dust will be sucked off their shoes as they step onto a grid in the hall. As they enter the changing rooms they will be dusted by streams of compressed air from 18 jets before putting on their nylon overalls. The building is pressurized to prevent dust particles from entering and contains 13 air conditioners.

The factory is one storey high, and its 200 by 100 ft grooved sheet aluminium walls stand on a brick base. Inside the walls and ceilings have been sprayed with 1600 gallons of plastic.

Semi-conductors Ltd was recently formed by the Plessey Company and the Philco Corporation of America.

Courses at Sunvic

Scientists have studied the uses of pulse height analysers in nuclear research in a series of intensive courses organized by Sunvic Controls Ltd at Harlow. Object of these is to provide those attending with detailed knowledge of the circuitry and functions of Sunvic's own PHA, special emphasis being laid on fault finding and servicing aspects. A wider understanding of PHA techniques and applications is aimed at, and a study of the instrument's uses in nuclear physics research and radiation spectroscopy is included.

The courses last a week and are divided into six parts, each including practical work on the instrument. Three courses have so far been completed, attended by representatives of scientific and industrial research establishments both in the UK and overseas.

A nominal charge only is made for accommodation during their stay at Harlow.

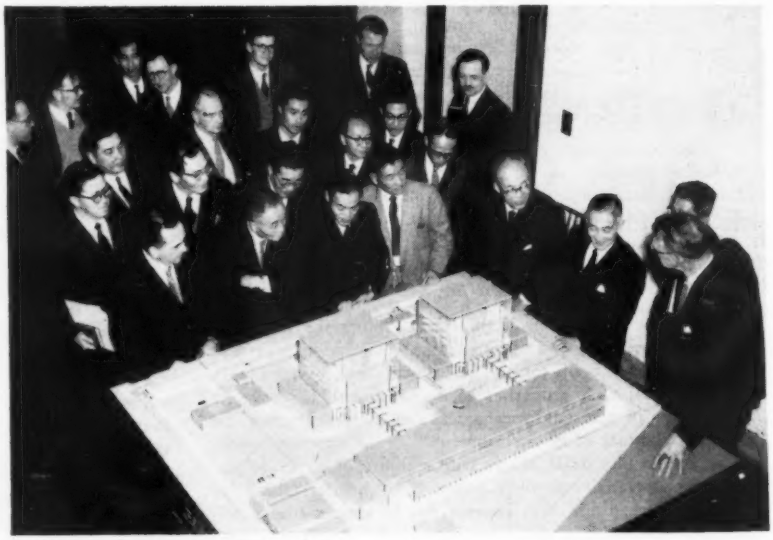
Nuclear lab for Parsons

New laboratories for research and development in the nuclear field are to be built at Heaton by C. A. Parsons & Co Ltd. Costing over £M1 the laboratories will make Heaton a major centre of peaceful nuclear research and bring more work to the North-East, says chairman Sir Claude Gibb. The company has taken this step because developments over the past year or so have indicated 'exciting possibilities of greatly improving present designs, which could lead to lower construction costs and higher efficiency.'

Building will begin shortly and should be completed by the end of the year. Among the first equipment to be installed will be the digital computer recently ordered by the company.

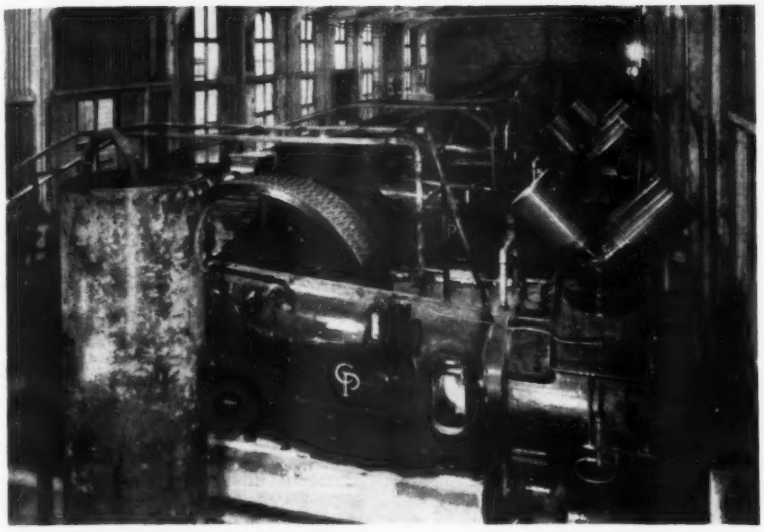
Van de Graaffs popular

The High Voltage Engineering Corporation is to double overseas facilities for installation and service of its Van de Graaff particle accelerators, announced company president Dr Denis M. Robinson recently. There are already 27 installations in Europe alone with several more on order. Arrangements are that the High Voltage Servicing Company



Japanese invite tenders

Recently in Britain for discussions on the possibility of buying an atomic power station of the British type, members of the Japanese mission are here seen at English Electric's works at Whetstone studying a model of Hinkley Point nuclear station. On Feb 19, before leaving, they invited tenders from the English Electric, General Electric and AEI-John Thompson groups for a 150 MW station



Tunnels for Berkeley

This Consolidated Pneumatic compressor installation provides air for tunnelling through sandstone from the Severn to Berkeley nuclear power station. Over one third of the main access tunnel has been completed and work is well up to schedule on the two 9 ft dia, 1000 ft long intake tunnels

Ltd, London, now under the control of the American company, will continue to service these and will expand stock and warehouse space by 100 pct to offer a complete selection of components for immediate shipment. Under Tom Fox, founder and managing director of HVSC, sales and engineering staffs will be more than doubled, special attention being given to training more men for installation and service. Eventually, HVSC will have responsibility for installation and maintenance of all Van de Graaff accelerators in Europe, Africa and as far eastward as Calcutta.

Harshaw crystals for sterling

It will now be possible to obtain Harshaw crystals for sterling and delivery will be faster. Nuclear Enterprises Ltd of Edinburgh have recently announced their appointment as exclusive concessionaires in the UK for sodium iodide and other scintillation crystals manufactured by the Harshaw Chemical Co of Cleveland, Ohio. Another of the projects planned by Nuclear Enterprises is the cutting, machining and polishing of rough ingot sections grown by Harshaws but finished and mounted in Edinburgh. These moves will result in lower prices for the crystals.

Hayward Tyler pumps again

The Hinkley Point nuclear power station will use Hayward Tyler pumps in its heat exchanger circuits. An order worth £125,000 for 48 pumps of the glandless type has been received from Babcock & Wilcox Ltd. These pumps are similar to those on order from Hayward Tyler Ltd, a member of the Platt Bros Group, for Berkeley, Bradwell and Hunterston nuclear power stations.

Babcock & Wilcox at Brussels

Special emphasis will be laid on nuclear power plants in the Babcock & Wilcox stand at the Brussels Universal & International Exhibition. Drawings and sectional models of plant for both land and sea service will be shown. Half the stand space will be devoted to a display by the English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Energy Group and included will be a large animated model illustrating their construction of the Hinkley Point nuclear power station.

The stand will be constructed with a central office entirely suspended from an arched roof of copper-anodized aluminium. Babcock & Wilcox are also contributing by financial and other support to the British Electrical and Allied Industries Exhibit which occupies a large stand nearby.

Clean air for Monsanto

Dust particles down to one micron in size will be removed with 99 pct efficiency from the air in Monsanto Chemicals new polyethylene factory at Fawley, Hampshire, and the filters will need servicing only once a year. First equipment to be used in Britain on this type of application, the fume and dust extraction plant will be designed, built and installed by Weatherfoil Heating Systems Ltd. They will also supply pressurized ventilating systems, the laboratories and other working areas being pressurized and fitted with airlock doors so that entry of airborne dust will be reduced to a minimum.

ZETA control by Cawkell

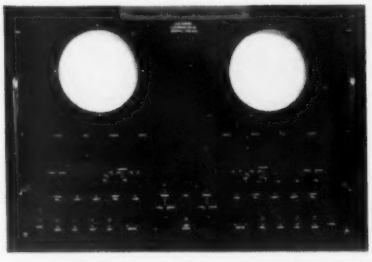
In the ZETA thermonuclear apparatus, first shown to the world at Harwell last month, the main measuring and monitoring equipment was designed, developed and manufactured by A. E. Cawkell, Electronic Engineers. It consists of two main sections:

1. The 8-channel recording oscilloscope type SC
2. The 2-channel *Memotron* storage oscilloscope

The SC equipment embodies eight separate amplifying channels with four 20th Century special double-gun tubes. The amplifiers are direct-coupled wideband units, and embody special balanced input circuits with attenuators, to discriminate against unwanted interference picked up on the incoming lines.

Two scan generators (timebases) are fitted, either of which may be switched to any or all channels. The scans may be triggered from an external voltage or by a variable rate internal trigger generator. A wide range of scan lengths with expansion is available and a special 'infallible trigger' circuit is used, making it impossible to trigger the sweep except by the wanted external voltage.

A time and voltage calibrating waveform generator is fitted. The device may



Similar to the equipment used on ZETA, this instrument incorporating two Memotron tubes can retain a trace indefinitely

be 'gated' or 'free running,' and generates a number of marker pulses, time spaced with crystal accuracy, and of an accurately known amplitude. A 'timing comb' form of trace is produced, markers of different time spacing having differing heights making for easy identifications. The time/voltage calibrator may be switched to all channels. The 'gating' facility is of interest, as it enables markers to be gated by, and for the duration of the signal.

Various photographic facilities are provided for shot number recording, frame wind-on, etc, and the trace is 'unblanked' when triggered. An interesting

auto-brightup circuit is fitted so that the spot brightness remains constant whatever the sweep duration.

The power requirements for such an instrument are considerable and four Cawkell 'Type A' inter-connected stabilized power supplies are used. The three floating supply rails provided are fully utilized as the entire equipment including amplifiers, calibrators, and scan generators is d.c. connected. Continuously variable stabilized e.h.t. supplies are provided for the four tubes.

Memotron equipment This is believed to be the first of its kind in this country. The Memotron tube incorporates a number of electrodes between its electron guns and the viewing screen. A fine wire 'storage mesh' is sprayed with electrons by the 'flood gun.' The voltage of interest is applied to a conventional deflector plate system controlling electrons from the 'writing gun.' Bombardment of the storage mesh by 'writing' electrons causes secondary emission, and the bombarded area assumes the same potential as an adjacent positive collector electrode.

This area permits passage of flood gun electrons which are accelerated to the viewing screen. The storage mesh is either at the 'written' (collector) potential, or at the 'unwritten' (flood gun) potential. Electrons from the flood gun continue to pass through the 'written' area indefinitely maintaining the 'picture,' until it is 'erased' by a momentary lowering of the collector potential. Two amplifier channels, similar to those in the SC instrument are fitted to the deflexion systems, and the sweep voltage is switched through from the SC.

Tailpiece This company was recently reorganized as Cawkell Research & Electronics Ltd. Directors are Mr A. E. Cawkell (managing) and Mr J. Rotheroe. Main products will continue to be electronic instruments, but by associating with Rotheroe & Mitchell Ltd, precision mechanical engineers, the company may also manufacture equipment to meet the increasing demand for combined electronic and mechanical devices in precision control systems. Address remains 6-8 Victory Arcade, Broadway, Southall, Middx, but is likely to be changed soon.

Weir pumps for Hunterston

Twenty Weir feed pumps have been ordered for the Hunterston nuclear power station by Simon-Carves Ltd. They include main and auxiliary pumps for both the high and low-pressure circuits, and will supply the water required for the steam generated in the steam-raising plants by the coolant gas from the reactor.

The eight electrofeeders, of the five-stage ring section type, to be used in the high pressure circuit will each have an output of 447,600 lb/h at 800 psi and the two auxiliary pumps will discharge 57,250 lb/h each at 772 psi. The main low-pressure pumps—also eight in number—each discharge 685,300 lb/h at 323 psi and the two auxiliaries will have an output of 85,000 lb/h each at 264 psi. The main pumps are to be fitted with Weir relay-operated automatic bypass valves to protect the pump in light-load operation.

Elliott computers demonstrated

A team from Elliott Brothers (London) Ltd toured Scandinavia recently demonstrating analogue computers and other Elliott products to invited audiences in Oslo, Stockholm and Copenhagen. Particular emphasis was placed on problems associated with nuclear reactors, but

J. C. NUTTER
computers and telemetering systems

general, marine and chemical engineering problems were also covered.

Led by Mr R. E. Hare, the commercial manager of Elliott's analogue computing division at Borehamwood, the team gave illustrated lectures and demonstrations in conjunction with their agents in each country. Mr J. C. Nutter, chief engineer of the company's nuclear division, who writes elsewhere in this issue, was also with the team. An Elliott G-PAC analogue computer was among the equipment flown to Scandinavia in advance of the party.

Nuclear congress

The 5th International Rassegna—Italy's Nuclear Congress—this June will cover worldwide nuclear industry and include discussions on the state of research in fusion, electronic instrumentation and the uses of radioisotopes in industry, agriculture and medicine. An exhibition and display will run concurrently with the congress. Subscriptions to congress and meetings, and bookings for stands are handled by Auger & Turner Group Ltd, 40 Gerrard St, W1, for the organizers, Rassegna Elettronica and Nucleare Roma. An electronic congress will follow immediately and last till June 28.

Ekco instruments for Danes

Denmark's new research reactor (DR3), to be constructed at Risö, will be equipped with Ekco nuclear instrumentation. This latest-type heavy water moderated research reactor will be the fourth in which Ekco Electronics Ltd have been responsible for the manufacture, installation and commissioning of the nuclear instrumentation and control circuitry. The instrumentation system will provide measurement and control of the nuclear process giving linear logarithmic and differential indication of reactor power, and an automatic safety system utilizing information obtained from both nucleonic and physical instrumentation for its operation. Instruments will measure radiation levels in various parts of the reactor area to ensure safety of working conditions.

In brief

Fission product detection gear for Hunterston has been designed and tested by the GEC in their laboratories at Erith in collaboration with Salford Electrical Instruments Ltd and the GEC Telephone Works.

Change of address to larger premises is announced by New Metals and Chemicals Ltd and Fleischmann (London) Ltd. New address will be Chancery House, Chancery Lane, London, WC2, Telephone Holborn 7415. Teleprinter and telegraphic addresses remain as before.

Rapid expansion has decided Evershed & Vignoles to open a branch office in Belgium on April 1. Situated at 142 rue Gallait, Bruxelles, the office, under Mr Samyn, will supply instruments in Belgium, Luxemburg and the Belgian Congo.

Southern Instruments Computer Division announce that Standard Scientific Supply Corporation of 808 Broadway, New York, 3, have been appointed as sole agents in the USA for the *Polarotrace*, the name under which their cathode ray polarograph is marketed there. Standard Scientific are members of a cooperative group capable jointly of covering the whole of the USA. The *Polarotrace* was shown during the recent 26th Exposition of Chemical Industries at the New York Coliseum, where it created a considerable amount of interest.

Access road to the site of Hinkley Point nuclear station has recently been completed by Taylor Woodrow Construction Ltd well ahead of schedule.

Commissioning Calder

Calder 'A' was not difficult to commission and in fact most of the teething troubles arose on the more conventional items of equipment. Reactor 1 has now been running for some twelve months and there is no doubt that it is a 'flexible and reliable unit which lends itself to routine control.' The next phase is to consider minor modifications which will lead to increased output and possibly some simplification in instrumentation and regrouping of instruments. These are the main conclusions reached by H. G. Davey in a paper presented to the BNEC symposium on nuclear energy, held in London on January 21.

NICHOLLS
The shapes, safe

Commissioning and operation of Calder is a rare topic—design aspects have so far had all the attention—and in this, one of the first authoritative papers on the subject, Davey gave a comprehensive survey of the approach and the problems.

Time allowed for commissioning of reactor 1 was relatively short—about three months—and it was agreed that parameters should be divided into two groups, desirable and essential, and that only measurements in the latter group should be made. This meant that commissioning could proceed safely and quickly but that some nuclear data would be obtained at a later date. Commenting on this during discussion, Davey said that his advice now to those who will be putting reactors into operation would be 'forget the divisions, desirable and essential, and do all the work necessary to achieve efficiency before commissioning.' At Calder, experimental work consisted essentially in making measurements to determine the critical size of the reactor and optimize the number and disposition of the control rods in the fully loaded reactor. Results obtained on reactor 1 were substantially implemented by the more detailed experimental programme during the commissioning of reactor 2.

Critical size When the first Windscale reactor was commissioned in 1950, the lattice constants had been calculated from relatively few experiments on sub-critical assemblies. The critical size was found to be very much bigger than predicted—in fact 1768 fuel channels were needed instead of the estimated 700. With the Windscale experience, estimates at Calder were more accurate—the critical mass was found to be the equivalent of 406 channels instead of the predicted 475. In reactor 1, it was also found that the reactivity was 1·27 pct more than expected, and on reactor 2 similar types of measurements on differently shaped fully loaded reactors were taken to investigate this. In reactor 1 steel bars, installed uniformly throughout, were used to absorb the excess reactivity to keep the number of control units required to a minimum. The neutron absorbing capacity of the control rods was also higher than expected and 48 rods were installed for the main calibration instead of the designed number of 70.

There followed an extensive programme of plant tests: measurement of gas flow rate, leak rate test—the initial rate of 100 lb/h was reduced by half by simple measures, blower tests followed by gas circuit inspection and checks on the fission product detection gear. After these tests it was found that 90 pct of the fuel cartridge caps were slack, and welding to the end cap stud proved to be the only solution.

Up to power On August 1, 1956, the first steam was generated and passed to the dump condenser. By August 27, maximum cartridge temperature was 375°C and an electrical load of 28 MW was achieved with a reactor heat output of 136 MW. The official opening by the Queen took place on October 17 under the same operating conditions, and the next day power was increased to 170 tMW by raising the blower speed to its maximum. A scheduled shut-down took place on November 5 for a month, and another in February when braces were fitted to the cartridges to prevent bowing. Subsequent operation has shown that the various alterations made at the shut-down have been satisfactory and near design conditions have been obtained with an output of 42 eMW and 180 tMW, with a maximum cartridge temperature of 408°C. In late August, 1957, power was increased to 200 tMW. Commissioning of reactor 2 began in December 1956 and it was in full operation the following February.

On maintenance problems, research manager J. Moore revealed during the discussion that it had been possible to get inside the heat exchangers for inspection. A very small amount of particulate activity had been found which could be dealt with, providing the radiation level is acceptable, wearing protective clothing and a face mask. On burst slugs, he said that of the three which occurred during the period May 1956 to August 1957, two were found to have pimples of uranium oxide on the uranium surface, and the third was due to a damaged or faulty weld.

DAVEY
The plant, reliable

Criticality problems Criticality as a factor in the design and operation of chemical plants came in for considerable attention. The film *Criticality*, made for the Authority by the Film Producers' Guild, was shown—for the first time to most of the conference—followed by a paper by C. M. Nicholls, Harwell, and A. C. P. Gillieson, Risley. In plants handling fissionable materials in quantity there is a possibility that criticality may occur when two sub-critical quantities approach each other too closely. There are two approaches to preventing this: limiting the amount of fissionable material present or using equipment with safe shapes and volumes. Quantity control can place a severe analytical load and operating responsibility on the staff and is usually only resorted to when more foolproof methods are not possible. In the more desirable but not always easily

attainable approach of control by suitable plant geometry, use is made of three fundamental shapes: the safe sphere, safe 'infinite' cylinder and safe 'infinite' slab. In these the principal dimensions are such that criticality cannot possibly occur for the fissionable material under consideration. For instance, in the precipitation and filtration of U235 compounds from solution, the precipitator becomes a long narrow cylinder of 5 in. dia or less. If more complex designs are necessary, it may be possible to fit the geometry to some hypothetical pattern known to be safe; otherwise detailed calculations must be made. Process selection can also be of considerable importance—in general, criticality will be less easily avoided in 'wet-way' than in 'dry-way' processes because the solute acts as a moderator.

Waste disposal With the stepping-up of the nuclear programme, the problem of fission product disposal becomes even more severe. By 1965 the annual production of fission products will be 10^9 curies after 100 days cooling, which would require a million cubic miles of sea water—or 0·3 pct of the total volume of the oceans—to bring the concentration down to the permissible level for drinking water. Improvement or radical alterations in existing disposal techniques will have to be made. This means that unless we are prepared to face an increase in the number of processing sites on the grounds of fission product disposal only, the separation of large volumes of liquor from its associated activity 'will have to be carried out much more efficiently than has hitherto been found necessary.' This is the burden of the paper presented by K. Saddington, deputy head of laboratories at Windscale, on fission product disposal. Current work in the UK is directed towards a separation process which gives such complete removal of fission products at the first stage that subsequent raffinates have negligible activity, and towards a completely salt-free separation process which would enable medium active raffinate to be evaporated by a large factor. The condensate would then be combined with the high active waste and the condensate—virtually free of activity—sent out to sea.

For high activity effluent, containment in leak-proof, shielded storage is the present accepted practice. This is very expensive—£100 to £200 per cubic metre—and means that it must be segregated from lower activity material on the site to prevent it being diluted and it must be concentrated by the maximum factor before storage. There is a fundamental difference between British and American practice in storing highly active liquors. The UK policy has been to store the acid concentrate in stainless steel tanks, while at Hanford, for instance, the acid liquors are neutralized before dispatch to final storage tanks lined with mild steel. This neutralization has reduced the corrosion problem to a maximum rate of 0·01 cm penetration per year. But all methods of storage in tanks is only a way of buying time while the development of permanent disposal methods proceeds. The two processes which have received the most attention are adsorption in montmorillonite clay and fused salt calcination.

No HAR's yet It will be some time before homogeneous aqueous reactors are applied commercially as many problems remain to be overcome, according to I. Wells of Harwell and E. Lofthouse of ICI who gave a paper on fuel processing in HAR's. Difficulties are largely associated with the containment of fluids, handling of slurries and maintenance of equipment in high radiation fields (see the article by Hurst, Wells and Newby, NUCLEAR POWER, May 1957). For maintenance of the neutron economy, the liquid fuel must be processed to remove fission and corrosion products, and several novel approaches are at present under investigation.

The story of the development of the Butex process for separating plutonium from reactor fuels was told by C. M. Nicholls, chemical engineering division, Harwell. The work was carried out at Chalk River and began in October 1947 and in May 1949, the plant, developed by the British team and constructed in a building made available to them by Canada, went into operation. Samples were dispatched regularly to Harwell for process chemistry studies. More elegant pilot separation plants have since been built and more efficient separating processes developed, but many of the accepted standards of practice were evolved in this work in Canada.

Two other papers completed the conference programme. J. T. Wood and J. A. Williams of Windscale reviewed the computation of the performance of a multicomponent solvent extraction system for separating uranium and plutonium from fission products by tributyl phosphate. In England specially for the conference, R. Galley of the French CEA, described the Marcoule plutonium plant which, in a few weeks time, will be obtaining industrial quantities of plutonium, nine years after the first milligram was recovered.

Atoms symposium for Sydney

A major symposium on the peaceful uses of atomic energy in Australia will be held in Sydney during the week June 2 to 6. No information on the papers to be presented is available so far but they will be divided into five main sections with their own chairman: materials, under Prof R. H. Myers; power engineering—requirements and reactors—under Dr H. G. Raggatt; power auxiliaries—fuel cycles, economics, chemical processing—under Dr F. W. G. White; basic sciences—nuclear physics, thermonuclear studies, radiochemistry—under Prof M. L. Oliphant; associated techniques—radioisotopes, active handling, instrumentation, health, education—under Prof H. Messel. Chairman of the general conference will be Prof J. P. Baxter who is chairman of the Australian AEC. The programme will also include excursions, public lectures, and an exhibition showing developments in uranium mining, nuclear power research and industrial uses of isotopes. Papers will come from a wide variety of sources both in Australia and outside.

First FBI nuclear conference

A comprehensive programme is planned for a conference on nuclear energy to be held by the Federation of British Industries in Eastbourne from April 10 to 12. Chairman will be Sir Claude Gibb, chairman of the Nuclear Power Plant Co. and an impressive committee includes D. E. H. Pierson, secretary of the UKAEA, J. F. Herbert, English Electric, Arnold Lindley, GEC, and Harry West, AEI-John Thompson. The provisional programme of papers is as follows:

Thursday, April 10

Impact of nuclear energy upon industry Sir Edwin Plowden, chairman, UKAEA.

Nuclear energy and the world's fuel and power requirements E. F. Schumacher, economic adviser, National Coal Board.

Financial and investment aspects, including home and overseas markets J. R. Cuthbertson, Lazard Bros & Co Ltd, and John Brodrick.

Survey of reactor types Dr D. J. Littler, Reactor School, Harwell.

Friday, April 11

Radioisotopes and their uses Dr H. Seligman, at present head of isotopes division, Harwell.

New materials for nuclear engineering L. Grainger, assistant director, metallurgy, UKAEA.

Reactor instrumentation M. V. Needham, assistant group manager (engineering), Elliott Bros.

Fabrication and processing of fuel elements C. Buck, chief engineer, chemical plant design office, UKAEA.

On the Saturday afternoon there will be a conducted tour of Harwell. Conference fee, including accommodation, papers, the Harwell trip, and a conference dinner, is £21. Application should be made to the conference secretary at 21 Tothill Street, London, SW1.

Tick **No 65** on reply card for further details

. . . clean air . . . pressurised buildings . . . high efficiency filters, vital for nuclear engineering techniques . . . equipment that extracts 99% of all dust particles, *down to one micron in size* . . . filters that require cleaning only *once* a year . . . for air treatment, designed to *your exact* requirements, contact Mr. Dawson of Weatherfoil's Air Treatment Division, 185 Bath Road, Slough, Bucks. *Telephone Slough 25561.*

NAMES IN THE NEWS

H. FOX WRIGHT

W. DALZIEL

J. SHARPE

T. E. POTTS

B. A. HENSLER

Mr W. Dalziel, production manager of the electronic and equipment group, of Plessey, and **Mr H. Fox Wright,** contracts manager, have been appointed executive directors of the company.

Canadian Pollard Bearings Ltd have appointed **Mr J. W. Gowland** to be manager of their new factory at Oakville, Ontario.

Mr J. S. Eppstein has been appointed chief engineer of Isotope Developments Ltd, and **Mr R. Y. Parry** has been made technical manager of the company. Mr Eppstein spent four years in the nuclear physics division at Harwell where he designed electronic equipment and Mr Parry was for some time in the nucleonics section of E. K. Cole Ltd.

Wakefield-Dick Industrial Oils Ltd have appointed **Mr J. W. MacMahon** as general manager of their industrial lubricants division in succession to **Mr R. J. Turner** who has retired.

Mr A. H. Campbell, divisional accountant of the North West, Merseyside, and North Wales Division of the Central Electricity Generating Board has been appointed deputy chief financial officer.

Mr T. E. Potts has been appointed a managing director of the British Oxygen Co Ltd. **Mr A. D. Smart** who has become finance manager of the company is succeeded as secretary by **Mr B. R. D. Clark.**

Martonair Ltd have appointed **Mr S. Teasdale** as a further technical representative in the north-west.

Mr Hugh H. Baird has resigned his directorships of Baird & Tatlock (London) Ltd and Hopkin & Williams Ltd and sailed for Australia at the beginning of February.

Mr S. Geipel, chairman of William Geipel Ltd, has been made vice-president of the newly formed Electric Cable Makers' Federation.

Mr B. A. Hensler has joined the board of Siemens Edison Swan Ltd. Mr Hensler, who is managing director of Siemens Edison Swan (Export), is on the board of several other companies including that of Associated Electrical Industries (Overseas) Ltd.

Dr Vannevar Bush has been elected chairman of the board of Merck & Co Inc. New Jersey. Dr Bush took a leading part in the development of nuclear fission in the US during the last war.

At Fulmer Research Institute **Mr W. R. Merton** has taken over the chairmanship following the resignation of **Mr Spence Sanders,** and **Mr J. G. Graham** has joined the board of directors.

Mr W. D. Opher has been appointed managing director of Vickers-Armstrongs (Engineers) as from Feb 1. He succeeds **Mr P. H. Muirhead.**

Mr J. Sharpe, who is chief engineer of the valve division of EMI Electronics, recently attended the Sixth Scintillation Counter Symposium in America where he read a paper on 'Developments in photomultipliers by EMI.'

The CEGB have appointed **Mr D. Clark** to be chief planning engineer. He was formerly station planning and development engineer.

As from Jan 1, **Mr N. G. Worster** became chief development engineer of Measuring Instruments (Pullin) Ltd.

Mr G. Leslie Wates, JP, who until recently was chairman and joint managing director of Johnson & Phillips Ltd died on Jan 22. Mr Wates had been associated with Johnson & Phillips since 1907.

CATALOGUES & BULLETINS

Hydraulic press, being used for the Bradwell pressure vessel, is described in the November 1957, issue of the *Whessoe Review*. Built for Whessoe Ltd by Fielding & Platt, the press has automatic controls, is the largest and most powerful of its type in Europe.

Mark 2 of their gas-liquid chromatographic apparatus is described in a new illustrated brochure just published by Griffin & George Ltd, Alperton, Wembley, Middx. Method is fully described, typical traces given and also a guide to column packings.

Impact extrusions is the subject of the latest catalogue published by ICI Metals Div, PO Box 216, Birmingham 6. Design features are illustrated and pamphlet gives photographs of shapes which can be produced more easily by extrusion than conventional machining or pressing.

Valves for RF Heating is the title of a thick spiral-bound handbook from the English Electric Valve Co. Triode characteristics are given in graph form as well as other useful data.

Brochure from the Atomic Power Department of United Shoe Machinery Corporation illustrates the work of their research division including systems for pressurized water reactors and fuel handling equipment.

Nucleonic gauges used for plastics, rubbers, paper, etc., are described in a brochure from Ekco Electronics Ltd. The beta-emitting source used requires no expensive screening.

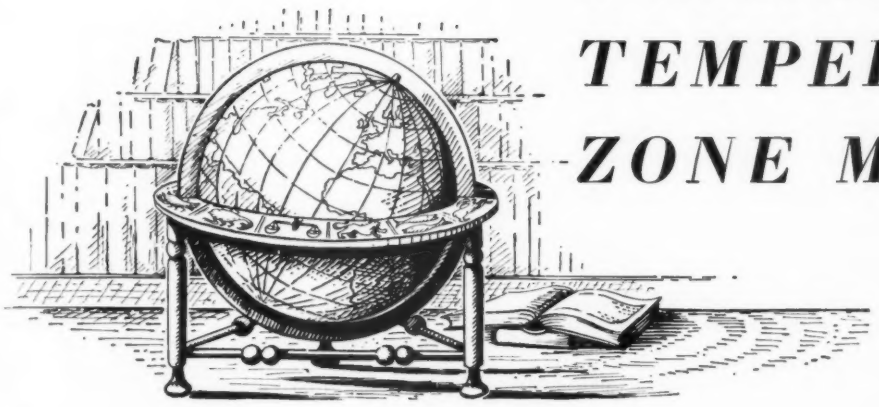
6 inches per second is the chart speed of a new disturbance recorder which is the subject of a leaflet from Ferranti. Instrument runs for a year without re-inking.

Ronald Trist & Co Ltd have issued a new catalogue giving full details and diagrams of their 'Mobrey' range of glandless magnetic level switches.

Tick No 66 on reply card for further details

RITCHIE CALDER'S *Signposts to the Atomic Age*

A MESSAGE FOR TEMPERATE ZONE MAN . . .



"TEMPERATE ZONE MAN IS INCLINED to preen himself. And why not? Has he not, in a brief two hundred years, achieved a mastery over Nature and an industrial prosperity which sets him above, and apart, from all others?

Consider the facts, however. The break-through to industrial prosperity began with the First Industrial Revolution and with James Watt's steam-engine. Machine-progress, initiated by British engineers, extended to Western Europe, then to America, and then to Eastern Europe. It depended on cheap, accessible fuel — fossil fuels (coal, oil and natural gas) which Nature had stored away millions of years ago.

Industry was anchored to geological deposits. Where fuel was cheap and ready-to-hand, factories created wealth, which could pay for education, endow research and provide capital for the new industries which burgeoned from such research.

The break-through became a run-away. In Asia, nearly 70 per cent of all energy is still "muscle-power", human or animal; in the United States only 4 per cent is so derived. The average Western worker, with a finger-flick of a switch, can have at his service the energy-equivalent of a hundred human slaves.

Now look at a map. Notice a fact that might temper the pride of Temperate Zone Man. The power on which his exultant prosperity has been based has come from fossil fuels. Take note that nine-tenths of the world's known coal reserves and four-fifths of the world's oil reserves lie north of latitude 20 degs. N.—just south of the Tropic of Cancer. Most of the so-called "underdeveloped" countries, lie south of that line and the inescapable fact is that, with the best will, they could have no share in a fossil-fuel Industrial Revolution, except as providers of food and raw materials.

Over two-thirds of the water-power potential of the world lies in countries by-passed by the First Industrial Revolution. Flood waters which bring perennial disasters could be harnessed to produce hydro-electricity. Water-sources, however, are dictated by geography. Transmission costs are high, if the electricity has to be carried to distant centres.

The New Industrial Revolution, in which those countries can share commands "footloose" energy—atomic reactors, which can be independent even of lines of communication, because, once installed, the fuel supplies are negligible.

For instance, a conventional power-station of 140 megawatts for New Delhi would need 2,000 tons of coal a day, permanently locking up 1,700 wagons and 30 locomotives to transport fuel from distant coalfields. An atomic power-station, on the same scale, would involve no such problem of transportation.

Look hard at that map. In 20 years time "footloose" atomic power, liberating industries from geology and geography, may have transformed it."—[R.C.]

* * *

MITCHELL ENGINEERING *are designing and constructing Nuclear Power Plant to meet world needs in the New Atomic Age.*

MITCHELL

Mitchell Engineering Ltd One Bedford Square London

RESEARCH REPORTS

The following reports have been made available to the public by the United Kingdom Atomic Energy Authority. They may be borrowed or photocopies obtained from the Science Library, London, Department of Industrial and Forensic Science, Belfast, the Mitchell Library, Glasgow, and the Central Libraries at Acton, Birmingham, Bristol, Kingston-upon-Hull, Leeds, Liverpool, Manchester, Newcastle-upon-Tyne and Sheffield. They are also deposited in the Copyright Libraries (i.e. British Museum; University Library, Cambridge; Radcliffe Science Library, Oxford; National Library of Scotland, Edinburgh; National Library of Wales, Aberystwyth) and in the Patent Office Library. Reports marked may be purchased from Her Majesty's Stationery Office.*

Reports are also available in the United States, from the USAEC depository libraries, a list of which will be found in NUCLEAR SCIENCE ABSTRACTS. Reports for sale may be purchased in the United States from: Sales Section, British Information Services, 30 Rockefeller Plaza, New York 20, N.Y.

AERE Harwell

Approach to critical experiments with slightly enriched uranium in natural water. *V. S. Crocker, W. G. Davey, K. R. E. Smith.* (July 1957. 26 pp) AERE RP/R 1810 4s*

The solubility of sulphates in uranyl sulphate solutions. (A tentative discussion). *E. Glueckauf.* (June 1957. 18 pp) AERE C/R 1900

Escape of gamma radiation from uranium rods in the pile heat evolved in the moderator. *J. S. Story.* (1949. 44 pp) AERE T/R 2218 7s*

The analysis of low level gamma-ray activity by scintillation spectrometry. *P. Iredale, D. L. O. Humphreys.* (August 1957. 10 pp) AERE EL/R 2326

The solubility of radiolytic gas in the homogeneous aqueous reactor core solution. *P. C. Davidge.* (August 1956. 14 pp) AERE C/R 2334 2s 6d*

LIDO. The engineering of physics design. *H. R. McK. Myder et al.* (Sept 1957. 52 pp) AERE R/R 2340 11s*

A note on the beta counting of U237 and Np239. *N. G. Stewart.* (Sept 1957. 4 pp) AERE HP/R 2383 1s 2d*

The preparation of deuterium sulphate. *D. E. Glanville.* (Feb 1956. 4 pp) AERE C/R 2386 1s 6d*

Some notes on an attempt to use T.T.A in conjunction with chromatography for the separation of rare earths. *F. W. Cornish.* (June 1952) AERE C/M 145 3s*

The gases evolved during the decomposition of anthracene by fission fragments. *D. F. Sangster.* (Sept 1957. 8 pp) AERE C/M 290 1s 9d*

The development and production of a mobile beryllium monitor. *T. W. Hodge.* (Sept 1957. 16 pp) AERE ES/M 24

Some experiments on enamelling aluminium. *O. Flint.* (1957. 4 pp) AERE M/M 175

Some notes on indium with special reference to its toxic properties. *F. M. Turner.* (August 1957. 4 pp) AERE MED/M 18 1s. 2d*

A small fission chamber. *D. Barnes, R. Aves.* (Sept 1957. 6 pp) AERE R/M 137

Design of travelling field induction pumps for liquid metals. *D. A. Watt.* (Sept 1957. 16 pp) AERE R/M 144 2s 6d*

Diffusion of fission fragments in slurry fuel elements. *W. M. Lomer.* (Oct 1954. 6 pp) AERE R/M 116 1s 9d*

Industrial Group

A high-frequency inductance level gauge for liquids in inaccessible locations. *D. F. Davidson, J. Pilling.* (Oct 1957. 18 pp) IGR R/CA-234

Recorder for an arc furnace. *W. Jacques.* (Oct 1957. 6 pp) IGR R/CA-247

An anthology of health physics data. *H. J. Dunster.* (Oct 1957. 59 pp) R & DB(W)TN-58 (3rd edition) 6s*

MARCH DIARY

ICE Institution of Civil Engineers, IMechE Institution of Mechanical Engineers, IEE Institution of Electrical Engineers, IChemE Institution of Chemical Engineers, IP Institute of Physics, PS Physical Society, SCI Society of Chemical Industry, IM Institute of Metals, IMet Institution of Metallurgists, IMM Institution of Mining and Metallurgy, IPE Incorporated Plant Engineers, SIT Society of Instrument Technology, Brit/IRE British Institution of Radio Engineers, RSH Royal Society of Health, WES Womens Engineering Society.

MONDAY 3
LONDON IEE The application of nuclear energy to power production *T. R. Puzey* 6.30 at the Institution

TUESDAY 4
LONDON IPE Plant engineers in a changing Britain *L. G. Northcroft* 7.00 at Royal Society of Arts, John Adam St, Strand, WC2
LONDON IChemE A contribution to the theory and practice of granulation *Prof D. M. Nebitt, J. M. Conway Jones*; The design of a simple mixer settler *J. A. Williams, L. Lowes, M. C. Tanner*, and other papers. All day at the Hoare Memorial Hall, Church House, SW1

WEDNESDAY 5
LEICESTER IPE Electrostatic filters *M. Penrose* 7.00 at Leicester Technical College

THURSDAY 6
GLASGOW IMechE A review of applications of radioisotopes to engineering *J. L. Putman* 7.30 at Royal College of Technology and Science

FRIDAY 7
EDINBURGH IMechE A review of applications of radioisotopes to engineering *J. L. Putman* 6.30 at North British Hotel

MONDAY 10
CHESTER IPE AGM followed by film, Mechanical seals 7.15 at Blossoms Hotel
LONDON RSH Papers on nuclear radiation hazards: training of local authority and hospital personnel, *Sir Ernest Rock Carling, G. B. Courtier, Dr W. H. P. Minto* 2.30 at Caxton Hall

WEDNESDAY 12
WOLVERHAMPTON BritIRE Analogue computers *K. C. Garner* 7.15 at Wolverhampton and Staffordshire Technical College, Wulfruna St
NEWCASTLE BritIRE Industrial television *S. G. Gobbi* 6.00 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Rd

THURSDAY 13
LONDON IEE The use of steel-tank mercury-arc inverters for generating medium frequencies for induction heating *D. L. Smart, J. L. Weaver* 5.30 at the Institution

TUESDAY 18
LONDON ICE James Forrest lecture by *Sir John Cockcroft* 5.30 at the Institution

WEDNESDAY 19
ROCHESTER IPE High pressure steam generation *O. S. Denham* 7.00 at the King's Head Hotel

THURSDAY 20
LONDON IPE The construction of a nuclear power station 7.00 at the College of Preceptors, Bloomsbury Sq, WC1

MONDAY 24
LONDON Physical Society Exhibition opens at Horticultural Halls, Westminster, SW1 continues to 27th

TUESDAY 25
LONDON IEE The atomic clock *L. Essen* 5.30 at the Institution

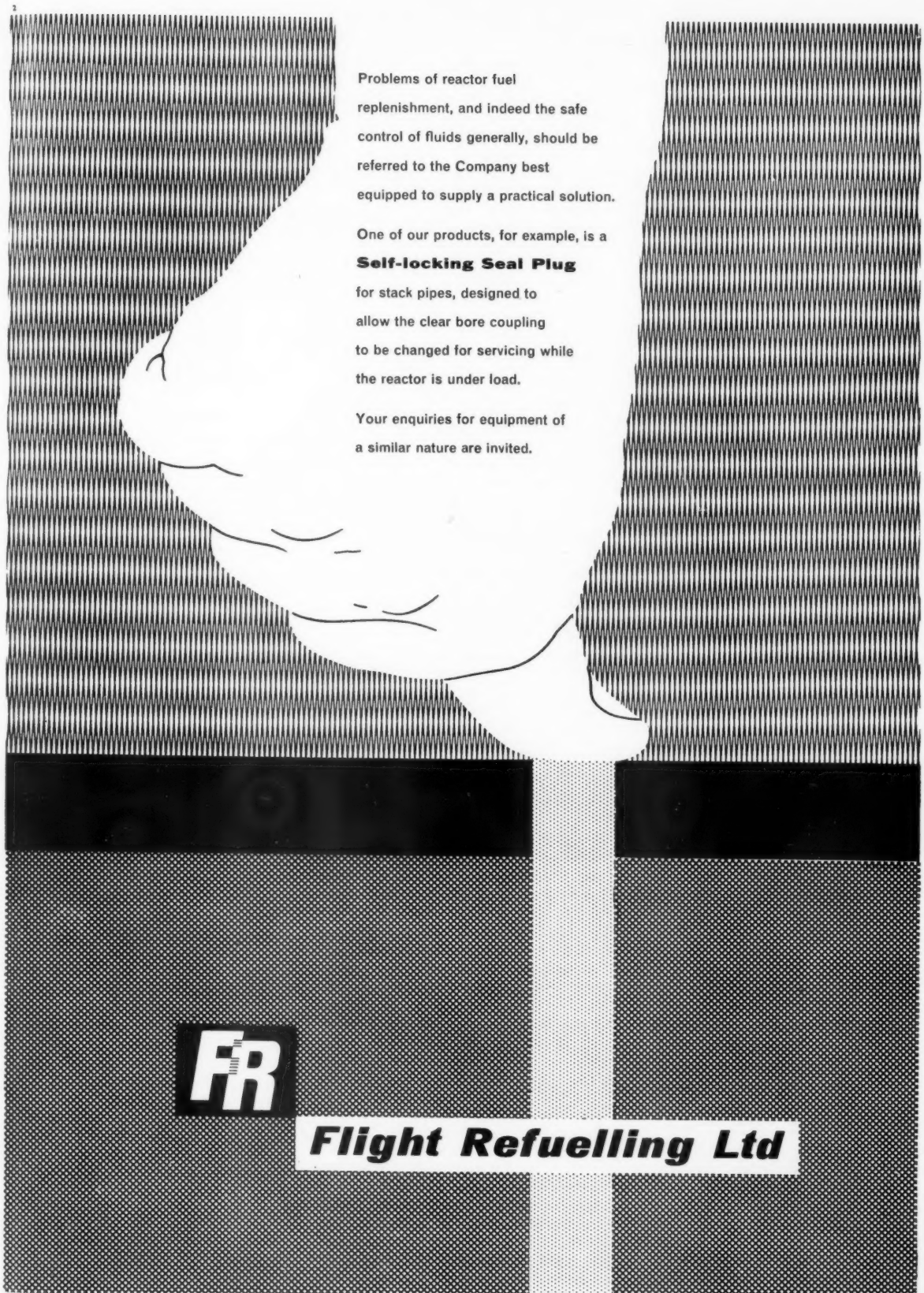
WEDNESDAY 26
MANCHESTER Brit IRE Electronic handling technique *R. N. Settle* 6.30 at the Reynolds Hall, College of Technology, Sackville St
LONDON IEE The objective for Euratom *Prof F. Giordani* 5.30 at the Institution

THURSDAY 27
CHATHAM IEE The application of nuclear energy to power production *T. R. Puzey* 7.00 at Medway College of Technology
MANCHESTER IMechE The commissioning and maintenance of plant at atomic energy factories *G. D. Ireland* 6.45 at Engineers' Club, Albert Sq

FRIDAY 28
LONDON IMechE Failure of a 60MW steam turbine at Uskmouth *A. L. G. Lindley, F. H. S. Brown* 6.00 at the Institution

MONDAY 31
LONDON SCI Transitional metal-hydrogen complex compounds *Prof G. Wilkinson* 6.30 at the Society

Tick **No 67** on reply card for further details


Problems of reactor fuel
replenishment, and indeed the safe
control of fluids generally, should be
referred to the Company best
equipped to supply a practical solution.
One of our products, for example, is a
Self-locking Seal Plug
for stack pipes, designed to
allow the clear bore coupling
to be changed for servicing while
the reactor is under load.
Your enquiries for equipment of
a similar nature are invited.
FR
Flight Refuelling Ltd
RINGWOOD ROAD WEST HOWE · BOURNEMOUTH · HANTS · Telephone: Blandford 501 Telegrams: Refuelling, Blandford

PATENTS

Porous fuel

Solid homogeneous reactors incorporating fissionable and moderating material in an intimate porous mixture have been receiving a good deal of attention lately and this Dutch invention suggests one way in which the materials can be arranged. The invention however also relates to heterogeneous reactors in which heat distributing material can be mixed with the fuel.

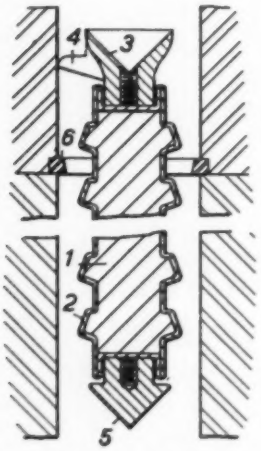
It is proposed to manufacture the homogeneous material—which may be in the form of metals or their compounds, provided that chemical compatability is assured—in the form of a porous mass fabricated into shapes such as packing units, perforated blocks or spheres, plates, rods or tubes. If gas is used as a coolant it is recommended that a voidage of 50 pct is allowed between the packing units to minimize pressure loss. If the packing material contains oxides, the gas should be CO_2 with a small percentage of O_2: if carbides or graphite is used, CO with possibly a little CO_2 could be used. Other suggested gases are He, H, or D and vapours and liquids are also considered as possible coolants.

Methods of preparing the porous materials are outlined at some length in the specification.

788,284 Improvement in or relating to nuclear reactors *Stichting Reactor Centrum Nederland*. Appn: July 16, 1956 Pubd: Dec 23, 1957

Shape of fins to come?

It is a known fact that as heat ratings in gas-cooled reactors increase, the optimum fin height on the fuel elements becomes shorter and shorter (see Fortescue, NUCLEAR POWER, May 1957 p 192). Here is a glimpse of a possible advanced type of fuel element for a gas-cooled reactor of high heat-rating. The inventors say that as the need for deep finning is reduced, so it becomes possible to consider accepting fuel element sheath materials having a reduced thermal conductivity and an increased neutron absorption so long as compensating advantages such as improved mechanical properties at high temperatures are obtained. One possibility is stainless steel.



789,257 GAS-COOLED FUEL ELEMENT

1 Uranium bar
2 s/s sheath
3 Top end fitting
4 Locating spider
5 Bottom end fitting
6 Turbulence ring

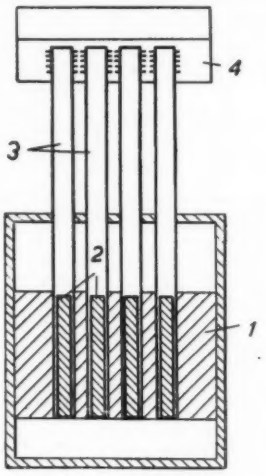
One form of element designed accordingly is illustrated here, the construction being apparent. The 'fins' are frustoconical in shape which give the element a different heat transfer performance according to which way up it is installed in the fuel channel. It is proposed to make these elements by casting the bar roughly to shape and then machining it. The sheath, in cylindrical form, would be slipped over the uranium bar and then rolled on to shape. End fittings are shown similar to those used at Calder but could obviously be adapted to particular needs. To increase turbulence, the sheath surface can be roughened and rings (6) can be inserted in the channel. Another type of element to achieve the same object is also described.

789,257 Improvements in or relating to fuel elements for nuclear reactors. *United Kingdom Atomic Energy Authority (Inventors: W. B. Hall and T. Davis)* Appn: Nov 5, 1955 Pubd: Jan 15, 1958

No flow through core

A method of removing heat from a reactor core with no fluid actually flowing through it is the subject of this invention. The advantages of this are that the power required for coolant circulation can be reduced and the temperature difference between the fuel and the heat transfer medium can be made very small.

The fuel element is contained in a sealed cylindrical can which is also partly filled with an intermediate heat transfer fluid. The top end of the can extends right out of the core into a heat exchanger through which the main coolant such as water or liquid metal circulates. The intermediate liquid has a critical temperature slightly higher than the temperature to which the coolant is to be raised but lower than that of the maximum permissible fuel temperature. If the ratio of the volume of liquid in the tube to the total volume of the tube is at least equal to the ratio of the specific volume of the liquid at atmospheric conditions to its critical volume, the pressure and temperature of the fluid in the tube tend to assume simultaneously their critical values. The effect of this is good heat transfer from fuel to coolant through the intermediate fluid in the critical or near critical stage.



785,886 CRITICAL PRESSURE ELEMENT

1 Core
2 Fuel elements
3 Heat transfer tubes
4 Main coolant

785,886 Improvements in or relating to nuclear reactors *C. A. Parsons & Co Ltd (Inventor H. H. L. Ritz)* Appn: March 17, 1955 Pubd: Nov 6, 1957

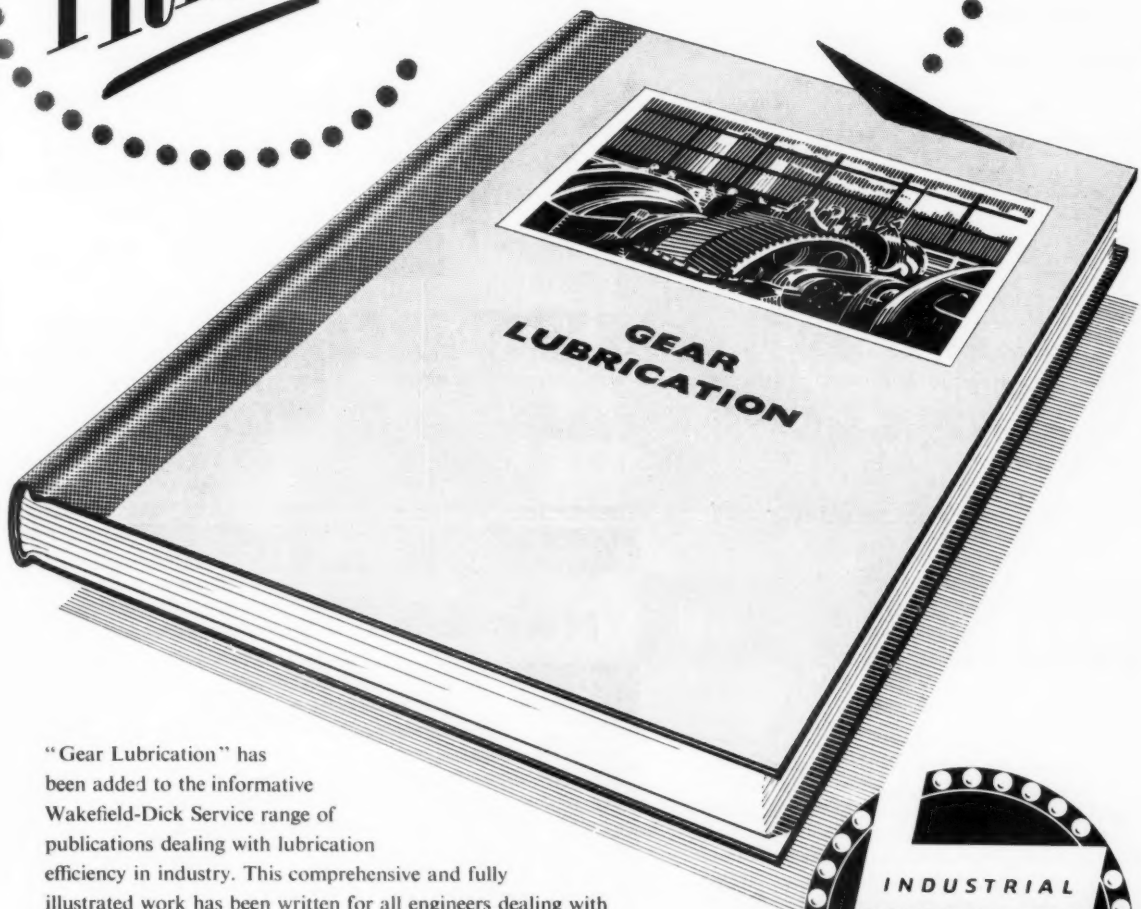
Dounreay control

In the published descriptions of the Dounreay Fast Reactor (see e.g. NUCLEAR POWER, June 1957) it was not made particularly clear how the reactivity control system operates because the information was withheld by the AEA at the time. Now a patent is published which seems to suggest how it is done. As disclosed last year, control of the DFR is by withdrawal from below the unmoderated core of certain fuel elements, the mechanism for doing this being partly immersed in the molten sodium primary coolant.

The object of this invention, one form of which is probably used at Dounreay, is to provide in one unit both fine control and emergency control and the specification describes a nut and screw mechanism driven through a magnetic clutch. Fine control is obtained by moving the fissionable material into or out of the core by the screw mechanism. When scram action is required, de-energizing the clutch sends the movable elements out of the core under gravity. The invention makes use of a 'ball-bearing' thread (British Patent 707, D17).

786,486 Improvements in or relating to nut and screw mechanisms. *United Kingdom Atomic Energy Authority (Inventor: J. A. F. Glass)* Appn: May 11, 1954 Pubd: Nov 20, 1957

FREE to all engineers concerned with gear lubrication



"Gear Lubrication" has been added to the informative Wakefield-Dick Service range of publications dealing with lubrication efficiency in industry. This comprehensive and fully illustrated work has been written for all engineers dealing with gears and their lubrication. Fill in and send to us the coupon below, and a free copy of "Gear Lubrication" will be despatched to you by return of post.

INDUSTRIAL
WAKEFIELD-DICK
LUBRICANTS

PLEASE SEND ME A COMPLIMENTARY COPY OF "GEAR LUBRICATION"

NAME OF COMPANY .....

ADDRESS .....

.....

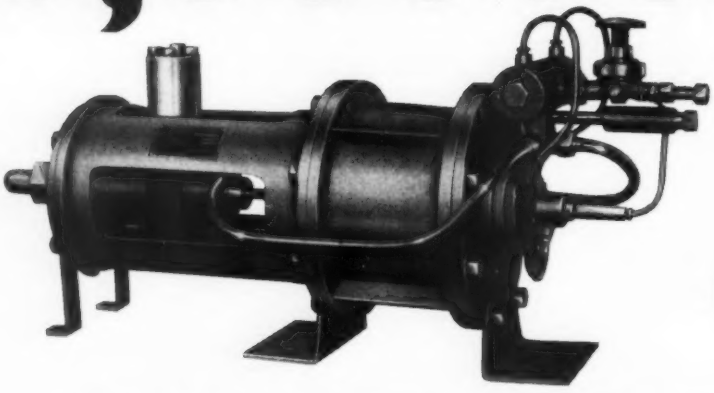
FOR THE ATTENTION OF

Post this coupon to Dept. P.D., Wakefield-Dick Industrial Oils Ltd., 67 Grosvenor Street, London, W.1. **N.P.**

Tick **No 69** on reply card for further details

55,000 P.S.I.

PRESSURE DEVELOPMENT & PRESSURE TESTING



FULLY AUTOMATIC FROM YOUR OWN AIR & LIQUID SUPPLY

by the latest development of the **AIRHYDROPUMP**

ALSO AVAILABLE IN MANY OTHER DESIGNS FOR VARIOUS PRESSURES AND REQUIREMENTS

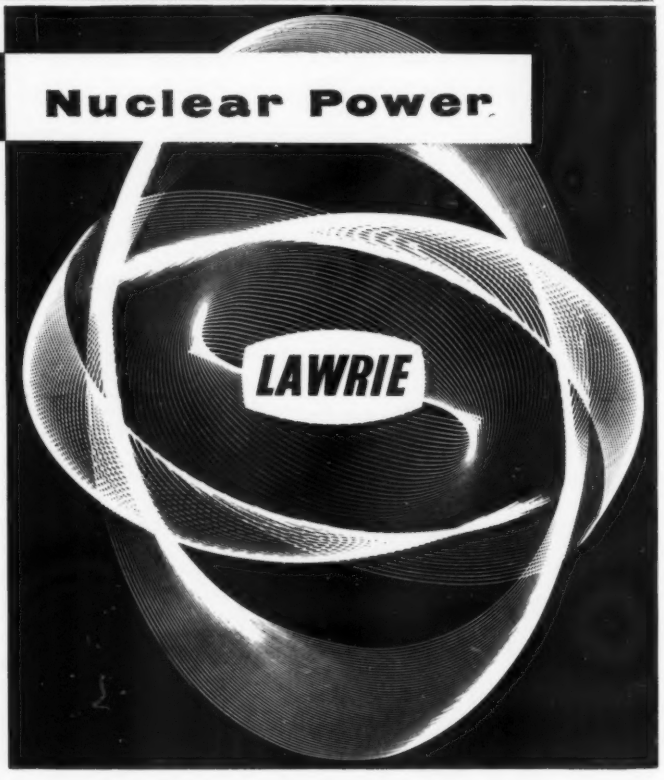
Full Details on Application

CHARLES S. MADAN & CO. LTD.

VORTEX WORKS · BROADHEATH ALTRINCHAM

Phone: ALT 2702 (3 lines) *Grams: VORTEX*

PIPEWORK and Nuclear Power



For many years Lawrie's have been producing fabricated pipework to critical B.S. standards for industrial and marine applications, and to A.P.I. standards for petroleum refineries. Add to this the fact that all Lawrie's welding is approved by Lloyd's—and other major inspecting authorities—and you will see why this Clydebank firm is noted for consistent top quality pipework. The stimulus of continually working to these exacting requirements places Lawrie's in an enviable position for meeting the hypercritical standards that can be anticipated in the Nuclear Age. Indeed, Lawrie's are already on the approved list of pipework contractors to the U.K. Atomic Energy Authority.

PUT YOUR PIPEWORK PROBLEM TO LAWRIE

J. & T. LAWRIE LIMITED

LIVINGSTONE STREET · CLYDEBANK · SCOTLAND

TELEPHONE: CLYDEBANK 2171/2/3

LONDON OFFICE: 34 VICTORIA STREET, S.W.1. *TELEPHONE: ABBey 4937 & 1847*

Tick **No 70** on reply card for further details

A68

Tick **No 71** on reply card for further details

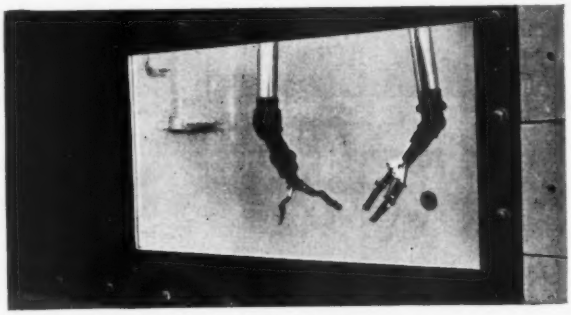
High Energy Radiation Shielding Glasses

Lead-Glass Blocks

The usual thickness is 4 inches but greater thickness, up to 9 inches in the case of type OW7 and up to 6½ inches for 927210 and OW8, can be supplied by special arrangement. The glass is stirred before casting: rectangular blocks can be supplied with ground and polished faces. These blocks are ideal for the smaller sized protective window and good visibility is obtained through several when used in series. The protective efficiency compared with that of lead is for radiation from a Cobalt 60 source.

Glass type	Refractive index(d)	Density grammes per cc	Lead equivalent	Total visible transmission for thickness		Maximum volume after grinding and polishing
				1"	4"	
OW7 (stabilised)	1.70	4.3	0.38	79%	59%	1300 cu. ins
927210	1.93	6.1	0.54	73%	56%	550 cu. ins
OW8 (stabilised)	1.93	6.1	0.54	49%	21%	550 cu. ins

(Stabilised glasses are resistant to darkening under the influence of high energy radiation.)



Shielding Glass in Polished Plate Form

The standard thickness is 1 inch and sizes up to 1 square metre in area can be supplied. The required window thickness is obtained by building the glass, in layers, in a suitable framing. Thus 30 pieces of the lower density glass will provide a window of the same thickness and protective efficiency as 30 inches of ordinary concrete: the denser glass is used for windows arranged in denser biological shielding walls. The lower density glass is also used for transparent boundary walls of zinc bromide cells: stabilised glass for the outer boundary.

Glass types	Refractive index	Density grammes per cc	Lead equivalent
Lime Soda (stabilised)	1.52	2.5	0.22
Lime Soda (unstabilised)	1.52	2.5	0.22
EDF Lead Plate	1.70	4.3	0.38

Please write for literature giving full technical details to:—

CHANCE-PILKINGTON OPTICAL WORKS

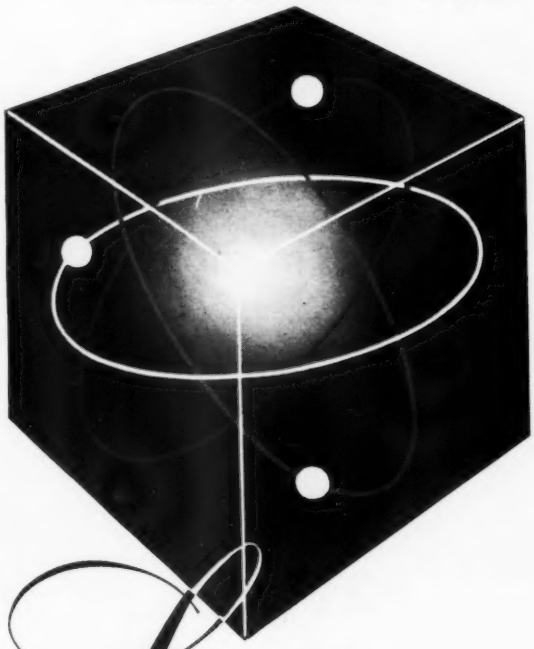
PILKINGTON BROTHERS LIMITED

GLASCOED ROAD, ST ASAPH, FLINTSHIRE

Tick **No 72** on reply card for further details

Protection

against radiation is a subject of constant research, and the need for skilled engineering in the manufacture of suitable protection methods will grow as Nuclear Power is more widely applied.



Lead

SHIELDINGS

without cavity voids, require skilled techniques for their manufacture. In the forefront of modern practice are JENKINSONS who are widely known for a high degree of skill in these directions.

Jenkinsons

CHEMICAL ENGINEERS

W. G. JENKINSON LTD.

ARUNDEL ST; SHEFFIELD 1

Phone 27438/9

Tick **No 73** on reply card for further details

MAKE LIGHT OF THAT

Heavy Duty

Equip with KING DICK

Precision-made under carefully controlled conditions, KING DICK Hand Tools set a superlative standard for Heavy Engineering work.

Please send for fully illustrated catalogue which will give you complete details of our range of hand tools.

BUY BRITISH!

BINGDON
KING DICK
HAND TOOLS

ABINGDON WORKS · TYSELEY
BIRMINGHAM 11 · ENGLAND

HEAVY DUTY RING SPANNERS
A formidable tool when used in conjunction with our special tubular handles.

OPEN-ENDED PODGERS
In B.S., B.S.W., American A/F and Unified Hex. sizes.

SLOGGING RING SPANNERS
Available in B.S. Whitworth, American A/F and Unified Hex. Sizes to suit all requirements.

FLAT 7½° SLOGGING RING SPANNER
In B.S., B.S.W., American A/F and Unified Hex. sizes.

PODGER-ENDED SOLID BOX SPANNERS
In B.S., B.S.W., American A/F and Unified Hex. sizes.

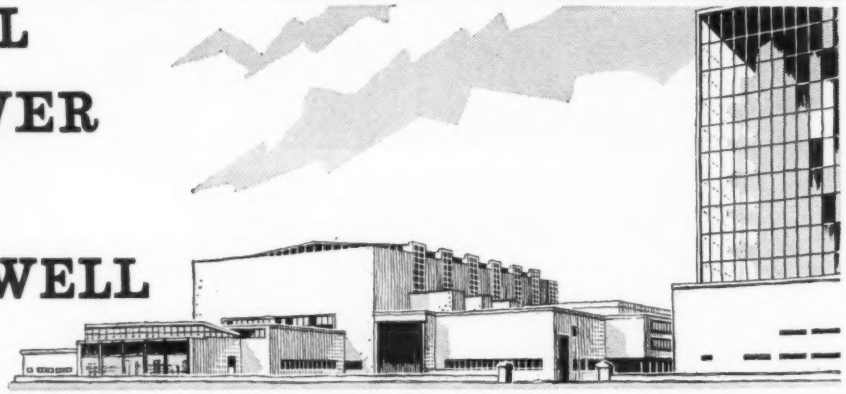
RING PODGER SPANNERS
A heavy duty tool supplied in all sizes to meet your requirements.

DOUBLE OFF-SET RING SPANNERS
Forged in Chrome Vanadium Steel to withstand the hardest work.

POWER OPERATED SOCKETS
For assembly lines, heavy engineering and Hicycle Tools. In ⅜", ½", ¾", 1", 1½", and 2½" Square Drive.

R.E.200

DIESEL POWER FOR BRADWELL



CROSSLEY engines for essential duties

Crossley Diesels have been chosen for yet another new nuclear power station, at present being constructed by the Nuclear Power Plant Company. Engines of the same design are in service or being installed in the United Kingdom Atomic Energy Authority's power stations at Calder Hall "A" and "B", Chapel Cross and Dounreay. Permanently installed will be three Crossley "ES Vee" 10 cylinder two-cycle Scavenge Pump Diesel engines, each rated at 620 b.h.p. at 1000 revolutions per minute and driving 450 kW. Lancashire Dynamo and Crypto alternators. These are automatic standby sets for the provision of current for essential services in the event of mains failure. The sets are supplied for Bradwell to Messrs. A. Reyrolle and Co. Ltd. Already installed on site is an "HSN 6" six cylinder two-cycle engine driving a 412 kW. alternator, this unit providing power on site during the construction period. Later two Goliath cranes will be installed, each powered by an "HSN 3" three cylinder straight line two-cycle Scavenge Pump Diesel engine driving Clarke Chapman 250 kW. alternators, one unit being mounted in one of the legs of each crane.

These two sets are being supplied to the order of Messrs. Clarke Chapman & Co. Ltd.

CROSSLEY DIESEL ENGINES

ΦC423 — CROSSLEY BROTHERS LIMITED · OPENSHAW · MANCHESTER 11

Tick **No 74** on reply card for further details

A70

'BOBY' Deaerators and Chemical Conditioning Equipment have been installed or are on order for

CALDER HALL
CHAPEL CROSS
BRADWELL

WATER
BOBY
TREATMENT

WILLIAM BOBY & CO. LTD
RICKMANSWORTH, HERTFORDSHIRE, ENGLAND
Telephone: Rickmansworth 4251 *

COURTBURN WELDING PLATENS

Courtburn Welding Platens provide a flat surface on which fabrications can be set up accurately.

Three sizes up to 8′ × 4′ are robustly made from finest quality close-grained grey iron.

"T" slots for 1 in. dia. holding down bolts are provided to the pattern illustrated, and there are four socket head cap screws for levelling purposes.

A number of platens may be placed side by side to form any required area of bed plate.

AN AID TO GREATER ACCURACY IN FABRICATING

Catalogue gladly sent on request

COURTBURN
POSITIONERS LIMITED

KEMPSTON HARDWICK, BEDFORD
Telephone: Kempston 2341-2

Tick **No 77** on reply card for further details

STAINLESS STEEL
SHEETS AND BARS

Why burden yourself with large stocks

go to **CASHMORES**

for 'off-the-shelf' delivery

BRITISH MATERIAL ONLY

One of the largest STAINLESS STEEL STOCKHOLDERS in the country.

COMPETITIVE PRICES · SEND FOR STOCK LIST

JOHN CASHMORE LTD

GT. BRIDGE · TIPTON · STAFFS. *Tel. Tipton 2181/7*

SM/JC.3099

MEN OF MILLIONTHS

The new problems of precision engineering born of nuclear research—the intractable metals, the unusual shapes, the exacting accuracy—are no novelty to us at Armstrong Whitworth. We have been solving these for years in aircraft and missile manufacture, and one result of this is the unparalleled array of precision machine tools that you will find in our temperature controlled, dust-free machine shop. Highly competitive costs have also been made possible by new techniques we have evolved, and all these benefits will be gladly shared with you. May we solve your problem?

FOR PRECISION MACHINING CONTACT:—

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD

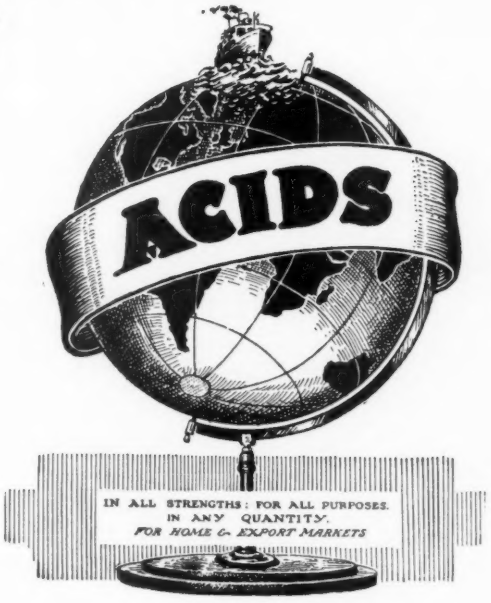
Baginton, Coventry. Telephone: Toll Bar 2261

A MEMBER OF THE HAWKER SIDDELEY GROUP

Tick **No 78** on reply card for further details

A72

Oleum (*All Strengths*), **Sulphuric, Battery, Hydrochloric, Nitric, Dipping and Mixed**
also
Distilled Water (*Pure*)



SCIENTIFICALLY PACKED FOR
TRANSPORT—ANYWHERE
in
Glass Bottles and Stone Jars (1 to 4 lbs.) (1 to 4 gallons)
Carboys (10 to 14 gallons)
Steel Drums (1 to 10 cwt.)

SPENCER CHAPMAN & MESSEL LTD

45 Park Lane, London, W1

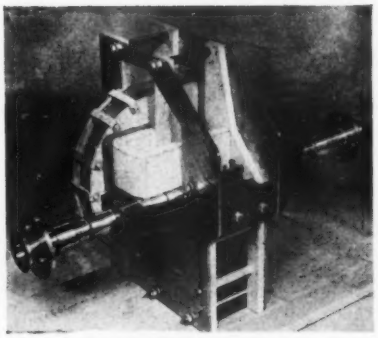
Works - Silvertown, E 16

Telephone - - - - GRO 4311
Telegrams Hydrochloric, Audley, London
Cables - - - Hydrochloric, London

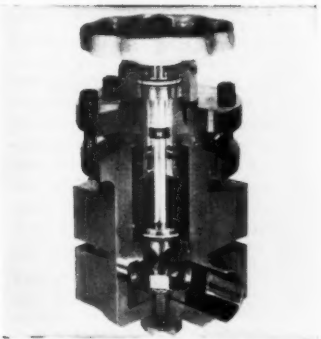
PALATINE

TOOL AND ENGINEERING CO., (SURBITON) LTD. SURBITON, SURREY

Telephone: Elmbridge 7261-2-3



Electro-Magnetic Pump



1" General Purpose Valve

MANUFACTURERS AND DEVELOPMENT ENGINEERS FOR NUCLEAR POWER PROJECTS

Pumps, Hi-Presflex Metallic Flexible Bellows and Valves manufactured for U.K. Atomic Energy Authority

Tick **No 80** on reply card for further details

Tick **No 81** on reply card for further details

Artists in Corrosion Resisting Steel Castings

- **Alloy Steels**
- **Stainless Steels**
- **Heat Resisting Steels**
- **Carbon Steels**

All castings can be machined in our modern machine shops

MILLENNIUM

LAKE & ELLIOT, LTD · BRAINTREE · ESSEX
Telephone: Braintree 1491

VARIACS for S-M-O-O-T-H Voltage Control

'VARIAC' is the *original*, continuously adjustable auto-transformer—and the only one having 'DURATRAK', a specially treated track surface. For varying the a-c voltage applied to any electrical, electronic, radar or communications equipment a 'VARIAC' offers considerable advantages over any other type of a-c control—it has longer life, absolute reliability, much increased overload capacity, resistance to accidental short-circuits and appreciably greater economy in maintenance. Voltages from zero to 17% above line are obtained by a 320° rotation of the shaft, which is equipped with an accurately calibrated direct-reading dial. Available in various sizes from 170 VA up to 25 kilowatts, including 3-gang assemblies for 3-phase working, 'VARIACS' are competitively priced and, compared with the losses of resistive controls often save their initial cost within a year.

Most "VARIACS" are now MUCH REDUCED IN PRICE: send for our new, profusely illustrated Catalogue 424-UK/16, which gives complete information on the entire range. HUNDREDS of models—all available promptly—most EX STOCK.

Claude Lyons Ltd.

76 Oldhall Street, Liverpool, 3, Lancs. Telephone: Central 3641
Valley Works, Hoddesdon, Herts. Telephone: HODdesdon 3007-8-9

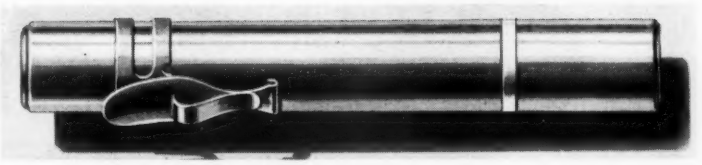
CL31

Tick **No 82** on reply card for further details

Tick **No 83** on reply card for further details

STEPHEN

QUARTZ FIBRE POCKET DOSIMETERS



Characterised by a very low natural leak, a high quality optical system and considerable mechanical strength, Stephen individual dosimeters are available in the ranges 0-0·2r, 0-0·5r, 0-5r, 0-50r, 0-150r, and 0-500r. Other ranges can be supplied to order. All except the 0·2r range are "air wall" construction.

STEPHEN · MITCHAM · LONDON

Pocket-size transistor charging unit has ample capacity with full control for charging all British-made pocket dosimeters. Weight 6 oz. (170 gms).

R. A. STEPHEN & CO. LTD., 120-126 LAVENDER AVE., MITCHAM, SURREY

FWS

WHO WANTS

An explosion...

with all its attendant cost and dislocation.

Yet it can easily happen.

Better play safe and specify

E.P.E. Flameproof Motors.

Buxton certified of course.

E·P·E

ELECTRICAL POWER ENGINEERING COMPANY (BIRMINGHAM) LIMITED

Bromford Lane, Birmingham, 8. Phone: STEchford 2261. Grams: Torque Phone Birmingham

London Office: 421 Grand Buildings, Trafalgar Sq., London, W.C.2. Phone: Whitehall 5643 & 7963

Tick **No 84** on reply card for further details

Have you investigated

Edison Tele-Voice?

Remote-Control Dictating

introduced first by 'EDISON'

Edison Tele-Voice saves money and time—it increases production and efficiency

Simplicity is absolutely necessary in a dictating instrument and the Edison TELE-VOICEWRITER affords it in full measure. Each TELE-VOICE station is a familiar 'phone-like instrument which is handled just like a telephone. Merely by pressing a button the Executive can record his work, listen back and make corrections in his dictation.

A TELE-VOICE network can contain three 'phones or three thousand—and stations may be easily reallocated or added as work loads vary. Each dictation 'phone is wired to an Edison TELE-VOICEWRITER—the key to any 'phone dictation system.

Both the central recorder and the new Edison Secretarial transcribing instrument are rugged and built for heavy-duty, all-day use. Their fully-enclosed design assures complete protection necessary for long life and trouble-free operation.

Let us assist you—telephone or write or call for particulars of Edison Remote-Controlled Dictation — the TELE-VOICEWRITER.

Thomas A Edison LIMITED

VICTORIA HOUSE · SOUTHAMPTON ROW · LONDON · W.C.1

Telephone: HOLborn 9988

BRANCHES AND DEALERS: Manchester Leeds Birmingham Glasgow Bristol Southampton Newcastle Belfast

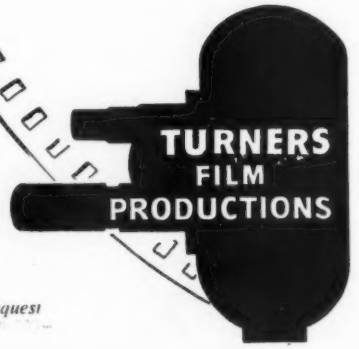
the EDISON TELE-VOICEWRITER

Complete Film Productions for Industry

by TURNERS of NEWCASTLE

Turners have already produced Public Relations and Prestige Films, Staff Recruitment Films, Scientific Record Films, Industrial Films, Advertising Films and Documentary Films for such firms as:

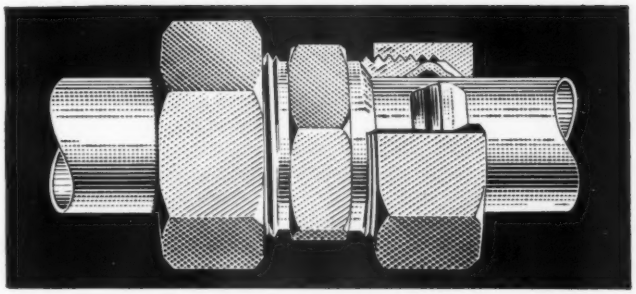
A. Reyrolle & Co. Ltd.
Central Electricity Authority
C. A. Parsons Ltd.
The Expanded Metal Co. Ltd.
Fibreglass Ltd.
South Durham Steel & Iron Co. Ltd.
Cleveland Bridge & Engineering Co. Ltd.
Express Dairy Co. (London) Ltd.
Houseman & Thompson Ltd.
The Royal Agricultural Society of England
The North East Industrial & Development Association

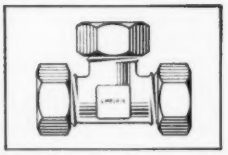


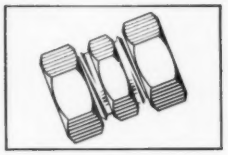
We will gladly supply further information on request

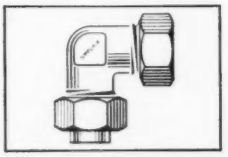
Camera House, Pink Lane, Newcastle upon Tyne. Tel: 2-5391.

SIMPLIFIX compression joints









for a perfect compression joint in minutes . . .

Simplifix takes all the bother out of pipe line assembly. Makes safe, leak-proof joints in a matter of seconds. No work to be done on the pipe ends beyond removing the burrs. No distortion to the piping because a special anti-friction washer prevents the pipe from twisting whilst the nut is being tightened.

● *Note: Simplifix fittings can be used on very thin walled tubing.*

A full range of fittings, elbows, tees, crosses etc., is available and illustrated in our catalogue which will be sent on request.

SIMPLIFIX COUPLINGS LIMITED

HARGRAVE ROAD · MAIDENHEAD · BERKS. TEL: MAIDENHEAD 2271/4

SIMPLIFIX

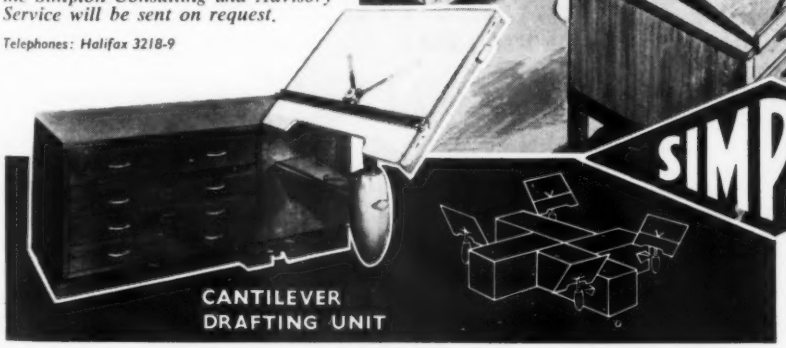
No time to lose

If Britain is to keep her lead in the nuclear energy field, the rate of productivity must be increased in all branches of the industry. This is specially true in the drawing office, for it is there that future achievements are now being planned.

The Simplon "Modular Line" units, two of which are illustrated here, can help draughtsmen to maintain their high standard. Designed as complete individual work stations, with the drafting board as the hub of the draughtsmen's activity, all unnecessary movement is eliminated and, since countless efficient room layouts are possible, all available space is utilised to the best advantage.

Full details of the Simplon units and the Simplon Consulting and Advisory Service will be sent on request.

Telephones: Halifax 3218-9



SIMPLON

DARGUE BROS. LTD.

NEW SIMPLON WORKS

HALIFAX, YORKSHIRE

Tick No 88 on reply card for further details

Tick **No 89** on reply card for further details

KLAXON INDUSTRIAL WARNING SIGNALS AND TRANSPORT EQUIPMENT

Buxton certified Mine Signal Equipment. Audible Signals for factories, railway yards, power stations, transport, etc. Heavy Duty Windscreen Wipers, and Direction Indicator Flasher Units.

KLAXON FRACTIONAL HORSE-POWER MOTORS

From 1/2000 to 1 Horse-Power. Synchronous. Commutator. Asynchronous Induction.

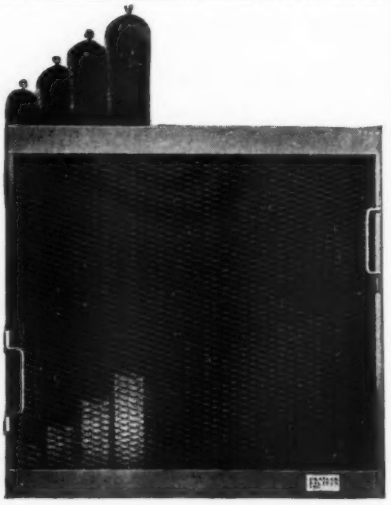
GEARED UNITS

Over 50 standard types. Output torques from zero to 2,500 lb. ins. Other types and performances designed for special requirements.

KLAXON LIMITED
Manufacturing Electrical Engineers. Estab. 1909.
49 UPPER BROOK ST., LONDON, W.1 *Tel.: Mayfair 9020*
WORKS—BIRMINGHAM. *Tel.: Acocks Green 1654*

KLAXON
every time!

THERE'S NOTHING WRONG WITH THE HEART OF THIS AIR FILTER!



The "heart" of a Heather Multi-Brush Air Filter is a finely graded screen of intermingling hair specially selected to withstand the varying humidity, and conditions of the dust laden air.
This unique, low-cost filter system does not require special cleaning equipment, fluids, replacement pads or fabrics — simply remove the filter brushes and free them from dust by shaking or suction cleaning. Heather Multi-Brush Air Filters may be built-up into units to provide the area necessary for any given air flow.

* ***Write NOW for brochure H69 which gives full details.***

HF **HEATHER FILTERS LIMITED**

28 ST JAMES'S PLACE · LONDON · SW1 HYDE PARK 7588

Tick **No 90** on reply card for further details

A78

photo: UKAEA

Photo shows a window built with Resilon in the High Activity Materials Handling Building, UKAEA, Harwell

RESILON

REINFORCED RESINS
FOR
NUCLEAR ENGINEERING

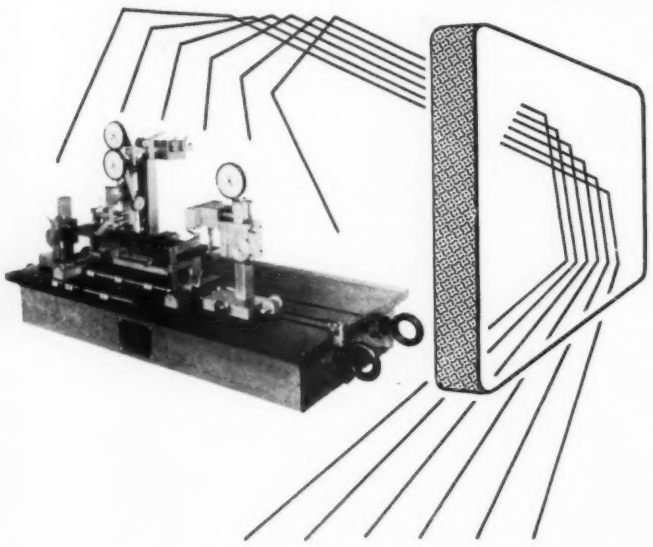
Mendip (CHEMICAL ENGINEERING) LIMITED

CHEMICAL ENGINEERS AND FABRICATORS IN CORROSION RESISTING MATERIALS

FELTHAM ROAD · ASHFORD · MIDDLESEX · Telephone: Ashford 4543

Tick **No 92** on reply card for further details

REMOTE DIMENSIONAL INSPECTION



Our contribution to the new High Activity Materials Handling plant at A.E.R.E., Harwell is metrology equipment designed for remote operation by master slave manipulators.

As designers and manufacturers of special purpose inspection equipment, let us solve your measuring problems. We can supply mechanical, pneumatic and electrical inspection equipment to your requirements. We are also at your service to undertake other types of precision engineering work and the development of prototype equipment.

GEORGE VERNON LIMITED

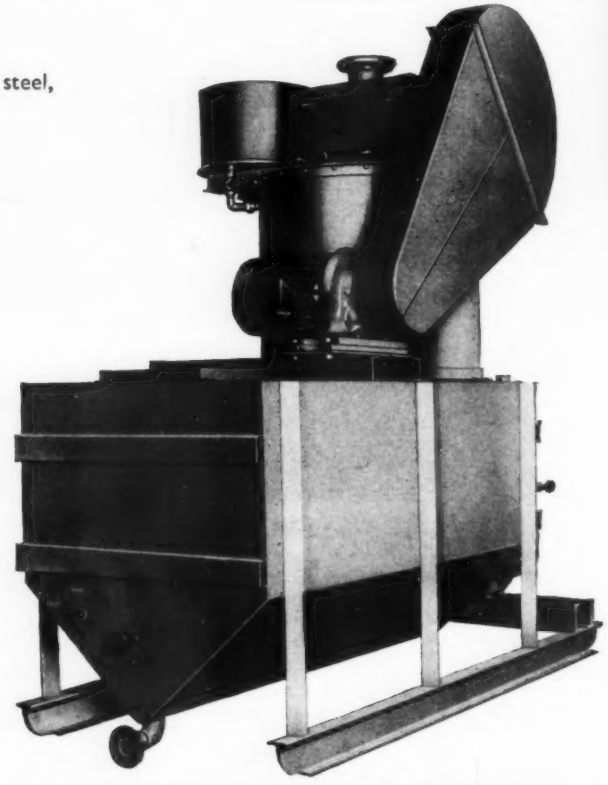
BALDOCK ROAD, STOTFOLD, ARLESEY, BEDS

Telephone: Stotfold 316

Fabrications for the chemical industry in mild steel, stainless steel, aluminium etc., by

YEWCO

Fabricated M.S. mixing plant specially developed by "YEWCO" for the mixing and blending of starches. Now in extensive demand in the paper and board trade.



The more exacting the specification, the more you need YEWCO

YORKSHIRE ENGINEERING & WELDING CO. (BRADFORD) LTD.

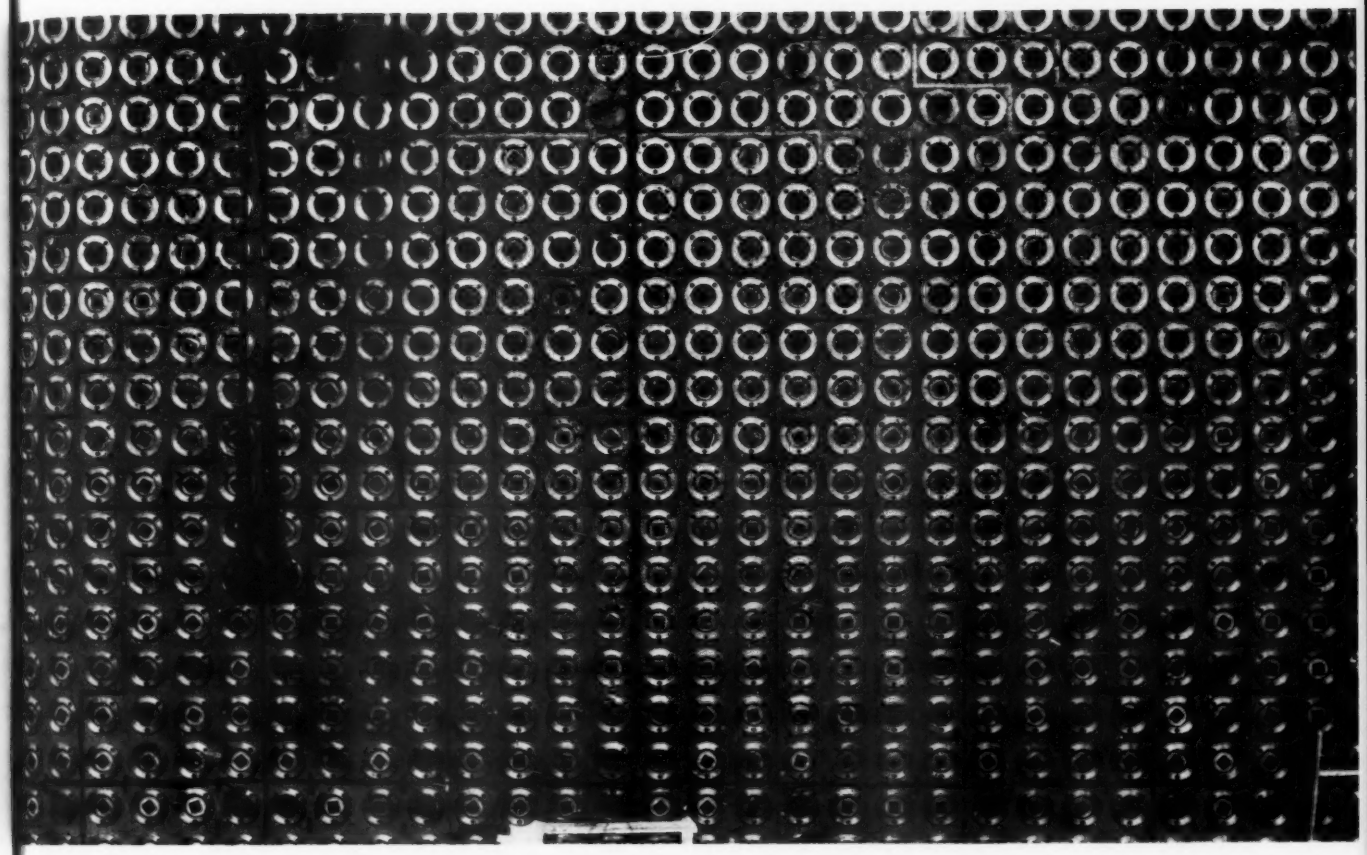
Friar's Works, Bradford Road, Idle, Bradford

Telephone: Idle 470 (4 lines) ***Telegrams: 'YEWCO' Bradford***

Tick **No 93** on reply card for further details

Tick No 94 on reply card for further details

A BREAKDOWN HERE COULD COST A FORTUNE



What is the most important piece of machinery in your factory ?

What would be the cost per day to your business if it were to break down ?

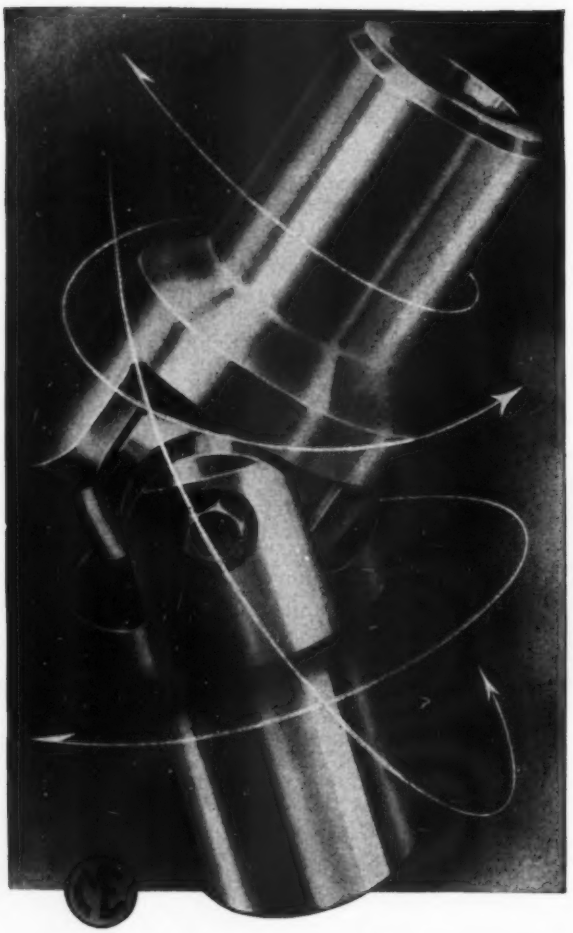
It is now possible to cover the loss of profits resulting from such a breakdown as well as the cost of repairing the machine itself.

Policies can be issued to meet the particular requirements of any business.

In this way you can be indemnified against the serious interruptions to your business which can be caused by machinery breakdown.

Should you feel in need of the protection of this new form of insurance we can send an engineer to advise you and inspect your plant.

Write to **D. H. EVERS,** *Industrial insurance consultant*
ONE ARUNDEL COURT · JUBILEE PLACE · LONDON · S.W.3



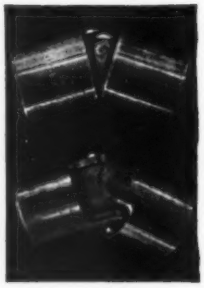
angular motion faithfully transmitted

Light Series Universal Joints are available in special designs for aircraft use, made in light alloy to Spec. L.40 anodised, with hardened ground steel trunnion pins, cadmium plated. They are designed with shank diameters to suit bore of standard aircraft tube and will withstand moderate tension or compression loads. Made in a wide range of sizes, they can be supplied with covers as required.

Patent Universal ball Joint combines high load capacity, simplicity of design and 92-98% efficiency. (N.P.L. certified.)

Hooke's Type Universal joint is suitable for high speeds and is inexpensive to fit.

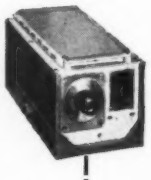
Grease Retaining Covers are available for all types and sizes of joints.



Air Ministry Gauge Test House Authority 89755/31

THE MOLLART ENGINEERING CO. LTD.
KINGSTON BY-PASS · SURBITON · SURREY · ENGLAND
TELEPHONE: ELMBRIDGE 0033-7 (5 lines) *TELEGRAMS:* PRECISION, SURBITON

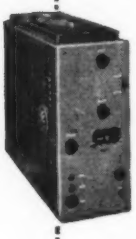
£600 is the cost of a simple, but complete closed circuit television link, consisting of camera, control unit and 14-inch picture monitor. Pye Television is already being widely used in industry and research to perform dangerous, difficult or uncomfortable jobs, thus releasing manpower to be employed more economically.



The Pye equipment is small and portable, simple to install and operate, and running costs

£600

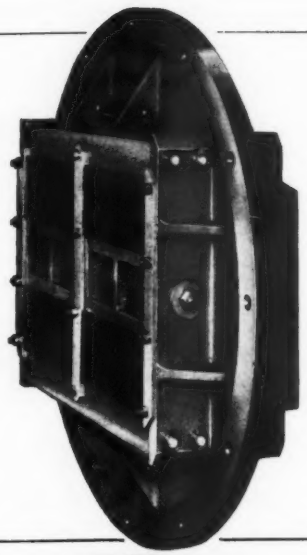
for PYE Industrial Television



are low. In addition to the three units illustrated, a variety of remotely controlled accessories and protective housings are available for special applications.

We shall be glad to advise you how television can help your company. In any case, may we send you our new comprehensive booklet and price list?

PYE LIMITED
Industrial Television Division
187 Regent Street, London, W.1 *Telephone: REGent 2712*



AMAL

A Special Unit constructed by us for the U.K.A.E.A.

We have had extensive experience in the manufacture of many engineering products such as

FLOWMETERS · FUEL PUMPS
JET CALIBRATING MACHINES
FUEL FILTERS · FLAP VALVES
FLAME TRAPS · GAS INJECTORS
FUEL PRESSURE REGULATORS

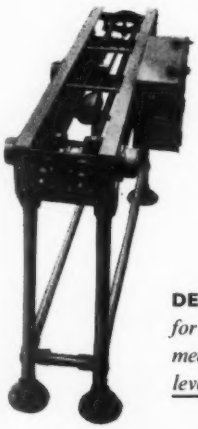
Now added to this List is Equipment for the U.K.A.E.A.

Enquiries to:
Amal Ltd · Witton · Birmingham · Phone Birchfield 4571 (6 lines)
A210

INSTRUMENTS FOR THE NUCLEAR ENGINEER

for fluid measurement and control

THE "R.M." DENSITY METER MK. 2



The density of piped flowing liquids, including slurries and corrosives, is continuously measured by the R.M. transmitting density meter. Density changes of the order of ·002 gm/ml. can be readily detected, with choice of electric or pneumatic signal.

DEVELOPMENT CONTRACTS
for special instruments to transmit measurements of flow, density and level have been undertaken.

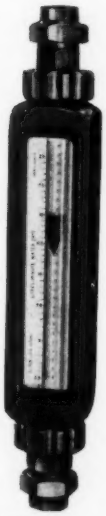
ROTAMETER FLOWMETERS

- INDICATORS
- TRANSMITTERS
- CONTROLLERS
- ALARMS

FLOWMETERS FOR EXTREME CONDITIONS:
Temperature: –200°C. to 400°C.
Pressure: Vacuum to 5,000 p.s.i.g.
Flowmeters for corrosive fluids.

FLOWS HANDLED RANGE FROM:
Liquid. . 0.5 c.c./min. – 7,000 litres/min.
Gas . . . . 2.0 c.c./min. – 115,000 litres/min.

Catalogue RP.2000/16 is free on request.

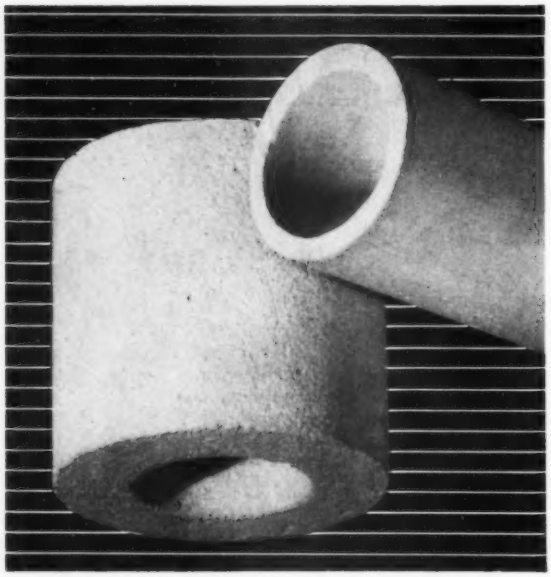


TYPE 900
"Metric" Series
Interchangeable tube and float from stock.

ROTAMETER
FLUID MEASUREMENT AND CONTROL
FLOW-DENSITY-LEVEL

ROTAMETER MANUFACTURING COMPANY, LIMITED, PURLEY WAY, CROYDON, SURREY
G35
Telephone: CROydon 3816

Tick **No 99** on reply card for further details



Most Uncommon Clay

AEROX Industrial ceramics have properties of strength, uniformity of pore size and variety of shape and dimension which commend them to many industries. They could probably help you.
Would you like to know more?

Filter Elements
Electrolytic Diaphragms
Aerators
Diffusers with Ebonite Plastic or Metal Fittings
Air & Gas Filters for pressures up to 7000 lbs. per sq. in.
Carbon Adsorber Filters

AEROX LIMITED

LEADERS IN A SPECIALISED FIELD

Ceramics Works, Hillington, Glasgow S.W.2.
Telephone: HALfway 4615/6

Engineering Works, Crompton Way, Crawley, Sussex.
Telephone: Crawley 25077

Tick **No 100** on reply card for further details

The economic conversion of heat into electrical energy depends on the efficient conservation of heat at each stage

The complexity of the heat handling problem in to-day's and tomorrow's nuclear power stations is one of the governing factors in the overall efficiency of the plant itself.

From the initial liberation of immense quantities of heat in the reactor, through each stage in the transfer and conversion of heat into electricity, it is of the utmost importance that heat losses by radiation and conduction be reduced to economic proportions. This aspect will be emphasised when the development of nuclear practice produces the higher operating temperatures now being demanded.

In supplying, from one source, a comprehensive range of thermal insulating and insulating refractory materials covering operating temperatures up to 1,370° C, Moler Products are contributing tangibly to the development of nuclear technology, while, at the same time, fully meeting the requirements of pulverised fuel fired power station boiler insulation. Full details of Fosalsil Insulating Bricks, M.P. Insulating Refractories (both in various grades) and the new Fosalsil Light weight Slab Insulation will gladly be supplied by our Technical Advisory Service.

MOLER PRODUCTS LIMITED

HYTHE WORKS, COLCHESTER, ESSEX
Telephone: Colchester 3191 Telegrams: FURMOL COLCHESTER

NP9

Tick **No 101** on reply card for further details

Where research counts . . .

PLASTIC LIQUID AND CRYSTAL PHOSPHORS

- PLASTIC PHOSPHOR N.E. 102 light output 65% anthracene available in all shapes and sizes up to one ton or in thin sheet form, or as fine Tubes for the CONSTRUCTION OF SCINTILLATION FLOW COUNTERS. Bulletin No. 11.
- PLASTIC PHOSPHOR N.E. 102 now available as filaments in kilometre lengths, with diameters up to 2 m.m. for the study of nuclear tracks in scintillation chambers.
- BORON POLYESTER PLASTIC PHOSPHOR N.E. 400 and N.E. 401 for neutron detection.
- LOADED LIQUID SCINTILLATORS in bulk or encapsulated, containing Pb for extreme X-ray sensitivity, and Gd, B or Cd for neutron detection (bulletins 9 and 9a).
- SCINTILLATING GELS for efficient internal counting of suspended materials (bulletin 9).
- SCINTILLATION CHEMICALS of highest purity P.B.D., POPOP, T.P.B., p-terphenyl, PPO, D.P.H., alpha-N.P.O., vinyl-toluene, styrene, xylene, toluene and methyl borate (bulletin 10).
- HARSHAW SODIUM IODIDE CRYSTALS. Exclusive concessionaire for Great Britain.

NEW LINE OF *PRECISION* NUCLEAR INSTRUMENTS

- Non Overloading Linear Pulse Amplifier N.E. 5202. Bulletin 14.
- Pre-Amplifier and Cathode follower N.E. 5202 A. (FAIRSTEIN TYPE). Bulletin 14.
- Single Channel Pulse Height Sorter N.E. 5102.
- Shielded Scintillation Head Unit N.E. 5501.
- Complete Human Body Counter Installation N.E. 8101.
- Multi-Channel Scintillation Spectrometer 8201 for Industrial Tracer Investigations.

Nuclear Enterprises (G.B.) Ltd.

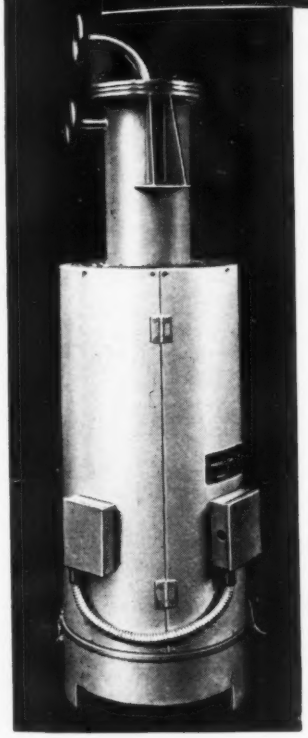
BANKHEAD MEDWAY, SIGHTHILL, EDINBURGH, SCOTLAND

Write now for Bulletins 9, 9a, 10, 11, 12, 13, 14 and the 1958 PRICE LIST.

Associate Company: Nuclear Enterprises Limited, 1750 Pembina Highway, Winnipeg, Canada

Telephone: CRA 4513

ISOMANTLES *for Atomic Plant...*



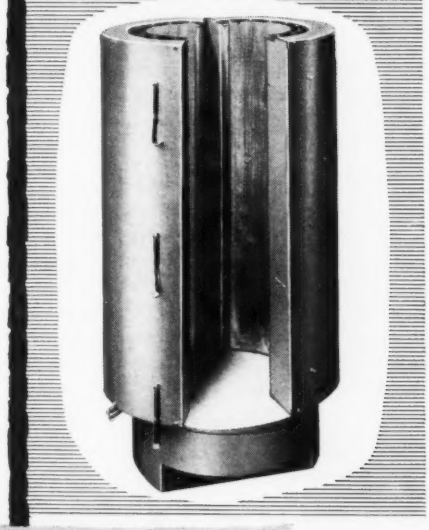
Hundreds of Isomantles assist Nuclear Development at Capenhurst, Springfield, Sellafield, Aldermaston, Harwell and other Atomic Centres.

Filter Shells and Reactor Vessels are heated by our "ISOJACKETS" as shown in the illustrations, in some instances up to 800°C.

Isotapes—flexible electric heating tapes—trace many thousand feet of process gas lines.

Isomantles have a wide range of uses. Can they help you with your special heating problem?

Visit our Stand No. 9 at the Oil & Colour Chemists Exhibition, March 11th—13th Royal Horticultural Hall



Leaflets on request to:

ISOPAD ELECTRIC SURFACE HEATERS

ISOPAD LTD., BARNET BY-PASS, BOREHAM WOOD, HERTS.

Telephone: ELStree 2817/8/9 *Telegrams:* ISOPAD, BOREHAMWOOD

Tick **No 102** on reply card for further details

. . . THE WORLD OVER

In this supersonic age, the men who test and fly the experimental jet aircraft of tomorrow are protected against gravitational pull, abnormal stresses and the rigours of rarefied atmospheres by scientifically-designed helmets, suits, boots and gloves.

On the ground, men employed in guided missile development, atomic and nuclear projects, oil refineries, chemical, engineering, mining, building and other industries need equally reliable protection against the hazards of their particular occupation. TIMEG, who have specialised in this field for years, can meet all their varying requirements — exactly, efficiently and speedily — from extensive stocks that are unsurpassed in quality and variety. In addition, TIMEG also supply a complete range of equipment for canteens and hostels.

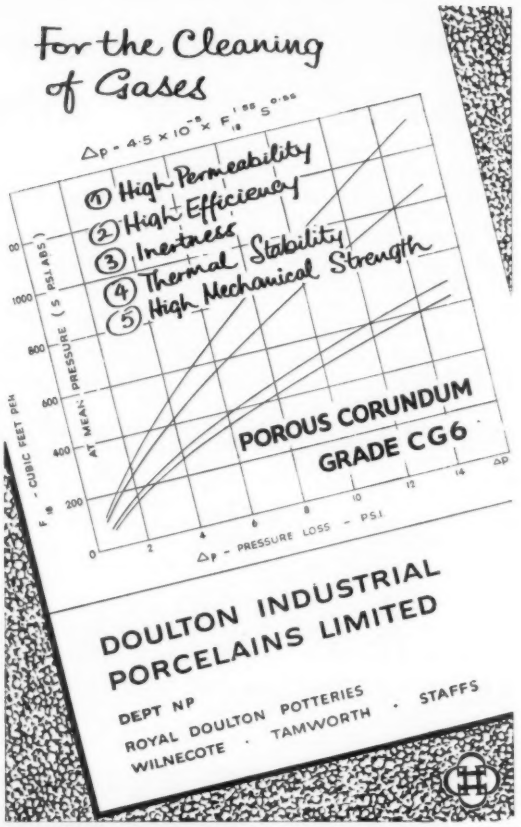
It pays to consult TIMEG before you make a final choice. Write or 'phone today for copies of their latest brochure and price list and see for yourself.

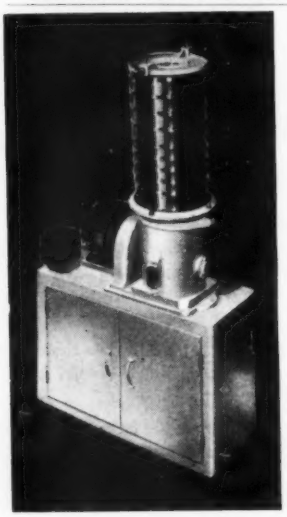
TIMEG LIMITED

Specialists in the design and manufacture of Industrial Protective Clothing

102 WARDOUR STREET, LONDON, W.1

Telephone: GER. 1191-2


For the Cleaning of Gases
$\Delta p = 4.5 \times 10^{-8} \times F_{18}^{1.85} S^{0.86}$
① High Permeability
② High Efficiency
③ Inertness
④ Thermal Stability
⑤ High Mechanical Strength
POROUS CORUNDUM
GRADE CG6
F_{18} - CUBIC FEET PER MINUTE AT MEAN PRESSURE (5 PSI ABS)
Δp - PRESSURE LOSS - PSI
DOULTON INDUSTRIAL PORCELAINS LIMITED
DEPT NP
ROYAL DOULTON POTTERIES
WILNECOTE · TAMWORTH · STAFFS



accurate particle size analysis

Simply vibrating or shaking test sieves by hand is not enough for an accurate sieve analysis of the particle size range of a material.

Vibration alone tends to aggregate rather than segregate particles, and shaking test sieves by hand is tedious and obviously inefficient.

The Inclyno Test Sieve Shaker, with a double movement that gyrates and jolts the test material around the entire surface area of the mesh of each test sieve, ensures perfect segregation of the various particle sizes in the shortest possible time.

The Inclyno Test Sieve Shaker is an essential unit for all laboratories and is standard equipment for sieve analyses in many government laboratories, nationalized industries and industry in general.

Operated by fractional h.p. motor and supplied complete with automatic time switch covering test periods up to 60 minutes. Three models available for all sizes of standard test sieves.

INCLYNO

TEST SIEVE SHAKER

Write or telephone Crawley 25166 for List IN 3203

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Tick **No 105** on reply card for further details

Tick **No 106** on reply card for further details

New Scintillators from N. & T.

Three new Scintillators are available from Nash and Thompson Ltd

1 **NATON II** A new plastic scintillator of extremely high efficiency, exceptional optical clarity and short decay time. In polyvinyl toluene base.

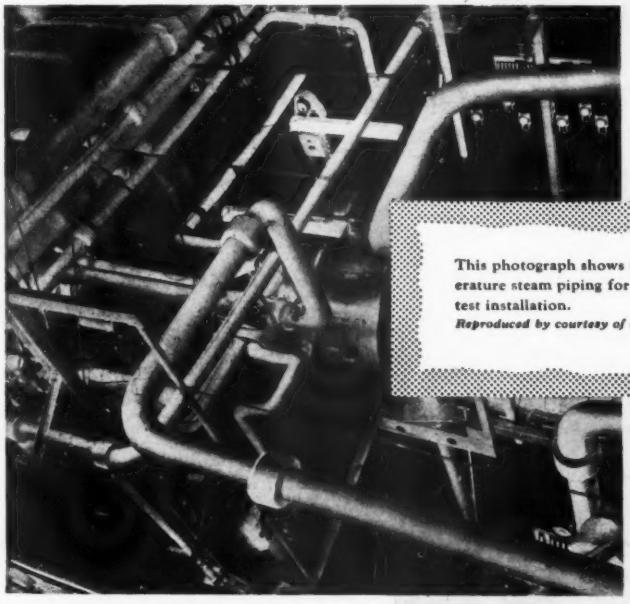
2 **N. II X-RAY** A modified form of our "air equivalent" scintillator: (see British Journal of Radiology Vol. XXX, No. 350, pp. 103, 104, 105).

3 **SCINTIPAKS** Heat-sealed polythene envelopes containing highly purified powdered components, ready mixed in the correct proportions, for adding to toluene or xylene to make highly efficient liquid scintillators.

FOR FULL DETAILS WRITE TO **Nash and Thompson** *LIMITED*

OAKCROFT ROAD · CHESSINGTON · SURREY · ENGLAND · Tel: Elmbridge 5252 Pbx · Cables: 'Nashton' Chessington

WHG/NT56



This photograph shows the high temperature steam piping for a Naval shore test installation.
Reproduced by courtesy of the Admiralty.

Let FERRANTI take the stress on Pegasus at Portland Place

The calculation of the stresses in any three-dimensional multi-anchor pipe system is one of the many tasks performed in the Ferranti Computing Service.

You have the pipes
We do the work
You get the answers

For further details of this pipe-stressing calculation or the Ferranti Computing Service phone or write to

FERRANTI LTD

LONDON COMPUTER CENTRE
21 PORTLAND PLACE, W.1.
Telephone: LANgham 9211
Works: WEST GORTON · MANCHESTER 12

DC51

Tick **No 107** on reply card for further details

Tick **No 108** on reply card for further details

LEAD FOR PROTECTION

The Technical Personnel of

THE LEAD DEVELOPMENT ASSOCIATION

are available at all times

to assist in your problems

on the protective qualities of Lead against Gamma-Ray and X-Ray

LEAD DEVELOPMENT ASSOCIATION
18 ADAM STREET, LONDON W.C.2
TELEPHONE: WHITEHALL 4175
TELEGRAMS: LEADEVEP, RAND, LONDON

Tick **No 109** on reply card for further details

It's certainly worth looking at!

Trust a cat to know a good thing when he sees it! And you can trust a welder to appreciate the value of "SIF-TIPS"—B.itain's leading we!ding quarte ly. It gives you all the latest news on Sifbronze welding rods and processes and answers the kind of problem you're meeting every day.

WHY NOT WRITE FOR A COPY NOW?

The Editor, "SIF-TIPS,"
Suffolk Iron Foundry (1920), Ltd.,
Stowmarket, Suffolk.

Please send regularly.....copy/copies of "SIF-TIPS."

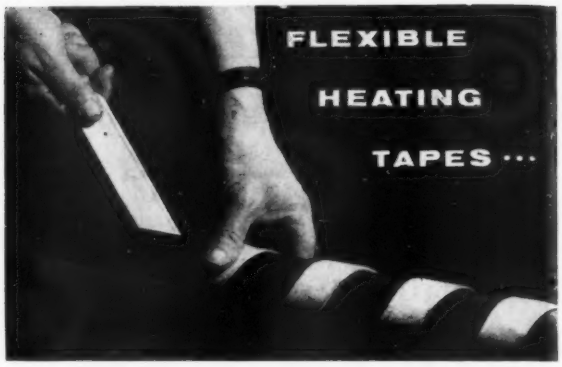
NAME .....

ADDRESS .....

.....

NPR2

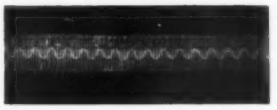
Tick **No 110** on reply card for further details



. . . maintain the flow with the temperature you want.

What heat do you want? What material do you have in the pipes ? Whatever the materials and whatever the heat up to 1000°C, Stabilag Heating Tapes provide the complete answer. Easily connected, simplicity itself in the installation, the various grades of Stabilag Tapes can adequately keep anything moving from low temperature viscous materials to molten metals. "Calsil" Heating Cables give temperatures up to 180°C, proofed or unproofed C 1 for up to 250°C, S 1 covering the 300°–400° range and the heavy duty Refrasil right the way to 1000°C.

Stabilag Tapes are produced under the most exacting conditions and represent the very finest products of their kind. Additionally, Stabilag have the technical backing and know-how which is a real and very necessary service to the user. Advice is willingly and freely given, problems are thoroughly investigated. Literature is available, please send for it.



Illustrated above is an X-ray of a typical tape section. The perfectly formed heating element is housed in materials of suitable insulation properties. As with all Stabilag products, heating tapes are of first-class quality.

For further details please write to:—

The Stabilag Co. Ltd. (Dept. A3), Mark Rd., Hemel Hempstead, Herts. BOXmoor 4481

VISIT OUR STAND No. J46 AT THE FACTORY EQUIPMENT EXHIBITION

Easy hand movement exerts controlled force of over 8 tons . . . ample for bending the thick-walled tubes increasingly used today. The double-acting hydraulic ram unit releases the bent tube from the former easily, without using wedges or hammer.

Write now for full details of the competitively priced TUBELA range of bending machines for hand, ratchet or hydraulic operation, including the 4-in. capacity Industrial Machines. One of them is bound to save you money!

Tubela

The Bending People

TUBELA ENGINEERING COMPANY LIMITED
North Eastern Office:
CUSTOMS HOUSE CHAMBERS
Quayside, Newcastle-on-Tyne
Telephone: 21180
Head Office:
FOWLER ROAD, HAINAULT
Essex. Tel. Hainault 4426-8

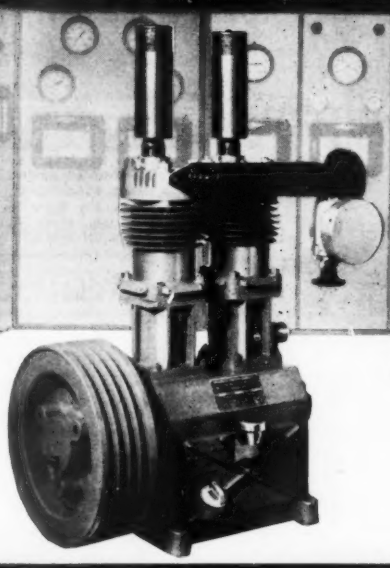
Tick **No 111** on reply card for further details

Tick **No 112** on reply card for further details

OIL FREE AIR
FOR INSTRUMENT PURPOSES

These W&J air compressors have been specially developed for use with modern pneumatic controllers and instruments, which require compressed air, free from oil. To ensure that the delivered air is completely free from oil in both vapour and droplet form, the special cylinders and pistons are isolated by means of a glanded piston rod from the normally lubricated crankshaft and connecting rod bearings.

Further details of these compressors can be obtained from the manufacturers.
Please write asking for leaflets Nos. 4 and 20.



The W&J range of Oil-Free Air Compressors comprises the following sizes:—

2½" bore 2" stroke single cylinder. Piston displacement 1.86 c.f.m. at 350 R.P.M. maximum.

2½" bore 2" stroke twin cylinder. Piston displacement 3.92 c.f.m. at 350 R.P.M. maximum.

5" bore 4" stroke single cylinder. Piston displacement 34 at 750 R.P.M. maximum.

5" bore 4" stroke twin cylinder. Piston displacement 68 at 750 R.P.M. maximum.

5" bore 4" stroke four cylinder. Piston displacement 136 at 750 R.P.M. maximum.

Maximum pressure 60 p.s.i. on continuous duty and 80 p.s.i. on intermittent duty.

WILLIAMS & JAMES (ENGINEERS) LTD.
GLOUCESTER · ENGLAND
TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

K/WJ.1931

is so important

and only the finest equipment is acceptable

Continuous - Cleaning Ventex Air Filters ensure a constant flow of clean air to vital functions of atomic power plant equipment. The filter is static and rigid, ensuring strength and reliability under all conditions of operation.

There is a Ventex Air Filter for every purpose.

VENTEX *Air Filters*

Send your enquiries for air filters to :

OZONAIR **ENGINEERING CO. LTD.**
ROCHESTER · KENT
Telephone : CHATHAM 45011/PBX

Tick **No 113** on reply card for further details

A89

Tick **No 114** on reply card for further details

Laboratory Apparatus and Glassblowing Company

RUBBERS - POLYTHENE - SILICONE
NEOPRENE - NYLON - P.V.C. PLASTICISED
P.V.C. RIGID - PERSPEX - P.T.F.E.

CONTAINERS and FABRICATIONS
TUBINGS and APPARATUS

Catalogue sent on request

77 Grosvenor Street, Manchester, 1

Telephone: ARD 6409

CENTRIFUGAL PUMPS

MULTI-STAGE
SPLIT-CASING

FOR EASY MAINTENANCE

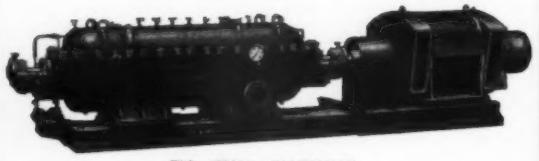


FIG. 4508M. 12 STAGES

LEE, HOWL & CO., LTD.

TIPTON, STAFFS.

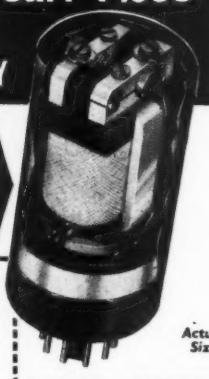
Will design Pumps for Special Duties

LONDON OFFICE:
375 REGENTS PARK ROAD, FINCHLEY, N.3

Tick **No 115** on reply card for further details

Tick **No 116** on reply card for further details

The Manning-Carr P.53C MINIATURE POLARISED RELAY



In dust-proof heavy gauge anodised aluminium can mounted on B9A base for plugging in.
(P53 original open non-plugging version still available.)
P53C BIASSED TO EITHER SIDE
P57 C/CS CENTRE STABLE
ALL TYPES FITTED WITH PLATINUM CONTACTS WHERE SPECIFIED

Data—A Sensitivity of 25 milli-watts and capable of handling mains voltage on the contacts with alternating currents up to 0.25 amps. Being polarised they have the advantage that the armature contact on P53 and P53C models can be biassed to lock in either direction by suitable adjustment of the contact screws which provides a useful facility where pulse operation is required. Speed of operation is high and the Relay will follow frequencies appreciably higher than 50 c.p.s. Resistance up to 7,000 ohms which is acceptable for Anode circuits. Alternatives to specification if required. **Sole Concessionnaires.**

Actual Size

POST OFFICE TYPES
3,000 & 600 RELAYS TO SPECIFICATION
Tropicalising, impregnating and Services jungle finish if required. Delivery 3-4 weeks.

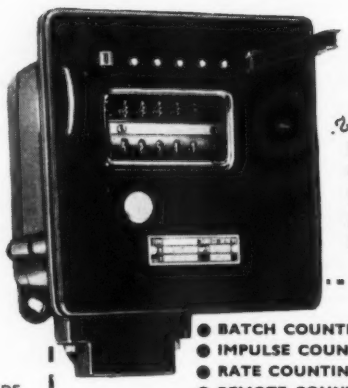
Manufacturers to H.M. Govt. Depts. and leading Contractors

L. E. SIMMONDS LTD.

5 BYRON ROAD, HARROW, MIDDX.
Tel. Harrow 7797/9 Grams SIMRELAY HARROW

Automation

starts with counting



Batch Counting Unit with Automatic Reset

- **BATCH COUNTING**
- **IMPULSE COUNTING**
- **RATE COUNTING**
- **REMOTE COUNTING**

SWISS PRECISION MADE Manufactured by Société des Compteurs de Genève, Geneva, Switzerland

The SODECO range of impulse counters and impulsing units provide the basic components for automation of counting, batching, positioning and other manufacturing processes. *Let us advise you on your problems.*

STONEBRIDGE CONTROLS & INSTRUMENTS

THE STONEBRIDGE ELECTRICAL CO. LTD.
6 Queen Anne's Gate - London S.W.1
Telephone: TRAfalgar 1444

Tick **No 117** on reply card for further details

Fleming
RADIO (DEVELOPMENTS) LTD.

A PERSONAL RADIATION MONITOR

This instrument measures the intensity of radiation in the immediate vicinity of the user, fitting into or clipping on to the breast pocket, and gives audible warning if it exceeds a preset level. Thus the user is protected at all times, having instantaneous warning of radiation at a level which could be injurious to health.

The design has made full use of the miniaturisation provided by transistor techniques, producing an instrument that is small, economical in battery power, and yet providing sufficient acoustic output that its warning cannot be ignored.

It requires no attention by the user, and provides no distraction, being silent until a field of sufficiently high radiation to operate it is entered.

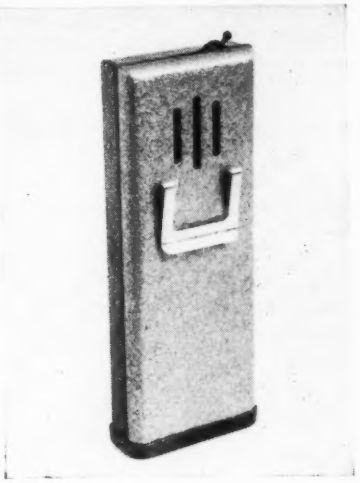
The psychological effect of urgency, conveyed by an interrupted tone, is made use of in the audible warning signal, which continues until the user leaves the region of harmful radiation. Standard preset operational levels are 5·0mR and 2·0mR, these levels being chosen to give a total dosage of 200mR or 80mR per 40-hour week respectively.

The overall dimensions of the instrument are 7 inches x 2½ inches x 1 inch.

Weight: With batteries 15 ounces.

Battery Life: 40-hours with non-rechargeable cell.
20-hours with rechargeable cell.

Halogen quenched tube with effective length of 4·0cms.

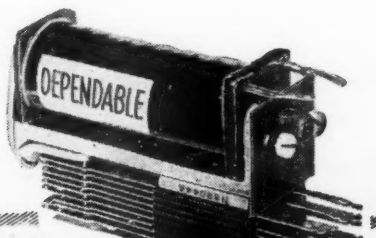


All enquiries to: Fleming RADIO (DEVELOPMENTS) LTD.

Designers and Manufacturers of:- Logarithmic Ratemeters, Pulse Generators, Time-Base Equipment, X-ray Dose Meters, Linear Amplifiers, Quench Amplifiers, Gamma-Radiation Monitors

CAXTON WAY, STEVENAGE, HERTS. (Stevenage 804)

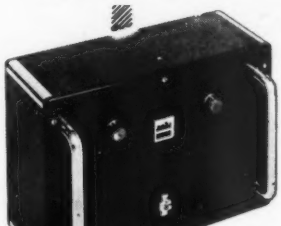
DEPENDABLE RELAY CO. *for* DEPENDABLE AUTOMATION



P.O. Type 3000 & 600
RELAYS

Manufactured to your specification to A.I.D. and I.E.M.E. standards.
COILS up to 80,000Ω. CONTACTS up to 8 amp.
INSULATION up to 5 kv. Prototypes 7-14 days.
PROMPT DELIVERY — PROMPT QUOTATIONS
SIEMENS high-speed types also supplied.
Specialists in tropicalisation. Transistorised relays.
Contractors to leading manufacturers, P.O. and Govt. Depts.

STANDARD SELF-CONTAINED CONTROL UNITS FOR



- PRODUCTION CONTROL
- COUNTING
- BATCH WORK
- PROGRESS
- TIMING
- SWITCHING
- POWER HANDLING
- LIQUID AND GRAIN LEVEL CONTROL
- TEMPERATURE AND FURNACE CONTROL

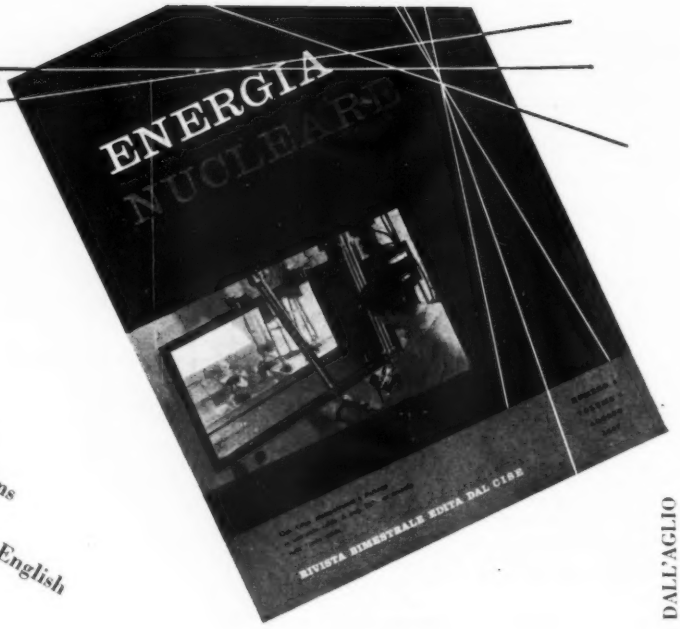
DEPENDABLE ELECTRONIC RECORDER
- Continuous Strip Chart
- 5in. graph
- 3 speeds
- Power driven pen.
- Immediate starting torque
- Full-scale drive 3 sec.
- "Plug in" oscillator chassis
- Black ebony finish Instrument Case.
- Research, industrial and medical applications.

12a, Tottenham Street, LONDON, W.1. *'Phone:* LANgham 7391/2 (NEAR GOODGE ST. STATION)

Tick **No 120** on reply card for further details

Publishers: CISE
Centro Informazioni
Studi Esperienze
Milano, via Serbelloni 1

ENERGIA NUCLEARE
is the Italian magazine dealing with the theoretical and practical problems in the atomic energy field.
Original research papers are published in English
Subscription rate for 1958:
12 issues Lit. 6000 (£3.10.0)



DALL'AGLIO

Sole Agents for Great Britain:

Subscriptions: Nuclear Power, Rowse Muir Publications Ltd. 3 Percy St., London, W 1

Advertising: Butlers' Advertising Service Ltd. 22 St. Giles High St., London, W C 2

BINDING Nuclear Power
The journal of British nuclear engineering

You often want to refer to NUCLEAR POWER . . .

. . . these Easibinders will hold up to 6 copies of NUCLEAR POWER (8 of Vol. 1) for quick and easy reference

12/6 each plus 1/6 postage and packing

TO ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W1

Please supply_____Easibinders for NUCLEAR POWER (Vol. 1 / other Vols.)

NAME_____

ADDRESS_____

_____

PRICE 12/6 BINDER, I ENCLOSE_____

CLASSIFIED ADVERTISEMENTS

RATES	Classified advertisements are charged at 4s. per line. Semi-display setting £2 per single-column inch. 5% is allowed to trade advertisers for six insertions. 10% for 12 consecutive insertions. Box numbers will be charged 1s. extra
REMITTANCES	Cheques and postal orders should be sent to Rowse Muir Publications Ltd with the order for the advertisement
PRESS DAY	Advertisements must be received not later than March 10 for the April issue
TERMS	All advertisements are strictly net and must be prepaid
HEAD OFFICE	All advertisements should be addressed "Classified Advertising," NUCLEAR POWER, 3 Percy Street, London, W1
BOX OFFICE REPLIES	NUCLEAR POWER, 3 Percy Street, London, W1

SITUATIONS VACANT

BABCOCK & WILCOX LTD.
ATOMIC ENERGY DEPARTMENT

Require a selected number of **QUALIFIED ENGINEERS** in this rapidly developing field. Experience in heat transfer, high temperature components or general mechanical and electrical design would be an advantage. Willingness to travel for limited periods in connection with overseas projects desirable.

Write giving full details of past experience to Assistant Secretary, Babcock & Wilcox, Ltd., 209 Euston Road, London, N.W.1.

The Industrial Group of

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

has a vacancy for a

DEPUTY DIRECTOR OF OPERATIONS

at its Headquarters at Risley, Warrington, Lancashire

who will be responsible to the Director for production matters in the Operations Branch and will control the production factories associated with the Group. He will be responsible for meeting production programmes within the technical limits laid down and for the efficient safety and economic operation of the various units, which include nuclear reactors, active chemical plants and separation processes.

Experience in the overall control of large scale production plants and a good degree in engineering, chemistry or physics are essential. Good personal qualities, together with drive and initiative, are required.

Salary will be from ***£3,500*** *upwards according to ability and experience.*

The post is permanent and pensionable

Suitably qualified persons are asked to write, in confidence to
THE DIRECTOR OF OPERATIONS
UNITED KINGDOM ATOMIC ENERGY AUTHORITY
INDUSTRIAL GROUP HEADQUARTERS, RISLEY, WARRINGTON, LANCASHIRE

MODELS

MODELS for planning

MODELS for prestige

MODELS for instruction

MODELS for experimenting

MODELS can save wear and tear amongst personnel and thousands of pounds worth of time and material.

MODELS can be an invaluable aid to sales staff.

RICHARD DENDY & ASSOCIATES of 4, 5 & 6 Seaton Place, Hampstead Road, London N.W.1, EUSton 7617, are makers of fine MODELS and invite your enquiries.

SUB-CONTRACTING

SITE work, Metal Polishing, Welding, Spraying. Countrywide service. Write for brochure to Stainless Equipment Co., Ltd., 72 De Beauvoir Crescent, N.1.

CAPACITY AVAILABLE for Plate and Sheet Metal Fabrication, General Machining and Erection. Special Machines and Prototypes to Customers' designs. Hobbs, Hart and Co Ltd (Telephone Leytonstone 1034).

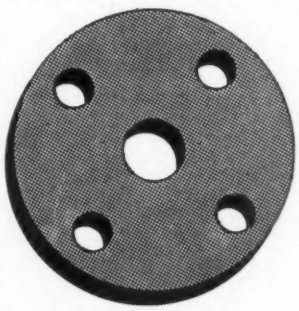
SECTIONAL BUILDINGS reconditioned and guaranteed, for site huts, accommodation, storage, etc. Smith Sections, Maud's Elm, Cheltenham. Telephone 56016.

CAST F.D.P. STAINLESS STEEL, GLOBE GATE & CHECK VALVES 600 lb. WP., flanged ends. Full particulars upon application. Write to Foster Wheeler Ltd., Foster Wheeler House, 5 Ixworth Place, London, S.W.5.

SERVICING LITERATURE. Industrial Handbooks Ltd write, illustrate and publish manuals and parts lists for nuclear components and systems. Rapier House, Turnmill Street, London, E.C.1. Clerkenwell 0548.

PUBLICATIONS

THE NUCLEAR POWER YEAR BOOK and BUYERS GUIDE — the indispensable reference work. Copies can be ordered. U.K.: price 42/- plus 2/- postage and packing. Overseas: price 63/- plus 2/- postage and packing. US, Canada: price $8 plus 50c postage and packing, from Rowse Muir Publications Ltd, 3 Percy Street, London, W1.



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

- ★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
- ★ SOLID DRAWN TUBES—FABRICATED PIPES
- ★ ROUND and HEXAGON BAR
- ★ PROFILES CUT TO ANY THICKNESS OR SIZE
- ★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

Tick **No 121** on reply card for further details

INDEX TO ADVERTISERS

Abingdon King Dick A70
Accles & Pollock Ltd A13
Acheson Colloids Ltd Feb
AEI-John Thompson Nuclear Energy Co Ltd Cover 1
Aerox Ltd A84
Air Control Installations Ltd A17
Amal Ltd A83
Appleby & Ireland Ltd Feb
Armstrong Whitworth Aircraft, Sir W. G. Ltd A72
Ashwell & Nesbit Ltd Feb
Associated Lead Manufacturers Ltd Feb
Avica Equipment Ltd Feb
Ayling Nuclear Equipment Co Feb

Bailey, N. G. & Co Ltd A44
Barlow-Whitney Ltd Feb
Birfield Industries Ltd A34
Birmetals Ltd A56
Birmingham Battery and Metal Co Ltd Cover 3
Bitulac Ltd A63
Boby, William & Co Ltd A71
British Acheson Electrodes Ltd Feb
British Ermeto Corp Ltd Feb
British Industrial Engineering Co Ltd A49
British Industrial Gases Ltd Feb
British Jeffrey-Diamond Ltd Feb
British LaBour Pump Co Ltd A21
British Oxygen Gases Ltd A7
British Paints Ltd A14
Burgess Products Co Ltd A12
Butterfield, W. P. Ltd A22

Cape Asbestos Co Ltd, The A48
Carruthers, J. H. & Co. Ltd Feb
Cashmore Ltd, John A72
Caswell Cranes & Erection Ltd Feb
Cawkell, A. E. Feb
Chance-Pilkington Optical Works A69
Chemical & Insulating Co Ltd Feb
Chivers, W. E. & Sons Ltd Jan
Courtburn Positioners Ltd A71
Crossley Brothers Ltd A70

Dargue Bros Ltd A77
Darham Industries (London) Ltd Feb
Darlington Insulation Co Ltd A58
Davison & Co (Hexham) Ltd Feb
Dependable Relay Co A91
Doulton Industrial Porcelains Ltd A86
Dowty Nucleonics Ltd A62
Dynatron Radio Ltd Jan

Edison, Thomas A. Ltd A76
Ekco Electronics Ltd A66
Electrical Power Engineering Co (Birmingham) Ltd A75
Electricity Supply Industry, The Jan
Electro-Hydraulics Ltd Feb
Electrothermal Engineering Ltd Feb
Endecotts (Filters) Ltd Feb
Energia Nucleare A92
Erhard, Iohannes A4
Ericsson Telephones Ltd Jan
Evans, I. & Son (Portsmouth) Ltd Feb
Evers, D. H. A81

Farr, Edward Ltd Feb
Ferranti Ltd A87
Fielden Electronics Ltd A55
Fielding & Platt Ltd A38
Firth-Derihon Stampings Ltd, The A52
Fleming Radio (Developments) Ltd A91
Flight Refuelling Ltd 141
Fraser & Fraser Ltd Feb

Geartight Unions Ltd A54
Gem Brushes (Luson) Ltd Feb
General Electric Co Ltd, The A31
Graviner Manufacturing Co Ltd A2
Grazebrook, M. & W. Ltd Jan

Hadfields Ltd A45
Harland Engineering Co Ltd, The A19
Harvey, G. A. & Co (London) Ltd Feb
Head Wrightson Processes Ltd A29
Heat Exchangers Ltd Feb
Heather Filters Ltd A78
Heraeus, W. C. GmbH A50
Hivolt Ltd Feb
Hoffmann Mfg Co Ltd, The Feb
Holman Bros Ltd Feb
Hopkinsons Ltd A23
Howden, James & Co Ltd Jan
Hull, F. & Sons Ltd Jan
Humphreys & Glasgow Ltd Feb

Ide, C. F., Engineering Ltd Feb
Ilford Ltd Feb
Imperial Chemical Industries Ltd Feb
Imperial Chemical Industries (Metals) Ltd Feb
Imperial Chemical Industries (Plastics Div) Ltd Feb
Industrial Exhibitions Ltd A61
Intermit Ltd A34
Irwin Technical Ltd Feb
Isopad Ltd A85
Isotope Developments Ltd Feb

Jenkinson, W. G. Ltd A69
Jessop, William & Sons Ltd A6

Keith Blackman Ltd A8
Kennedy, Allan & Co Ltd Feb
Kent, George Ltd A46, A47
Kenyon, William & Sons Ltd A3
Klaxon Ltd A78
Klinger, Richard Ltd A15
Kodak Ltd Feb

Laboratory Apparatus and Glassblowing Co A90
Lake & Elliot Ltd A74
Lawrie, J. & T. Ltd A68
Lead Development Association A88
Lee, Howl & Co Ltd A90
Lincoln Electric Co Ltd A41
Lloyd & Ross Ltd Feb
Lloyd, F. H. & Co Ltd Feb
Londex Ltd Feb
Lyons, Claude Ltd A74

Madan, Charles S. & Co Ltd A68
Magnetic Valve Co Ltd Feb
Mancuna Engineering Ltd A36
Marston Excelsior Ltd Feb
Mendip (Chemical Engineering) Ltd A79
Metropolitan-Vickers Electrical Co Ltd Cover 2
Mirrlees, Bickerton & Day Ltd Feb
Mitchell Engineering Ltd 139
Moler Products Ltd A84
Mollart Engineering Ltd A82
Moore, W. & E. Ltd Feb
Mountford, Fredk (Birmingham) Ltd Jan
Mullard Ltd A10
Murex Ltd Feb

Nash and Thompson Ltd A87
Newalls Insulation Co Ltd A16
Newburgh Engineering Ltd Feb
North British Chemical Co Ltd Feb
Nuclear Enterprises GB Ltd A85
Nuclear Power Plant Co Ltd, The A37

Osborn, Samuel & Co Ltd Feb
Ozonair Engineering Co Ltd A89

Palatine Tool & Engineering Co (Surbiton) Ltd A73
Pascall Engineering Co Ltd, The A86
Paterson Hughes Engineering Co Ltd Feb
Pearson, T. B. & Sons Ltd A32
Philips Electrical Ltd A1
Photostat Ltd Feb
Physical Society, The A18
Pollard Bearings Ltd A53
Powell Duffryn Carbon Products Ltd A30
Power Auxiliaries Ltd Feb
Proops Bros Ltd Feb
Pye Ltd (Industrial TV Division) A82
Pyrene Co Ltd, The A26
Pyrotenax Ltd Feb

Racal Engineering Ltd Jan
Rawlplug Co Ltd, The A27
Rocol Ltd Feb
Rotameter Manufacturing Co Ltd A83
Ruston & Hornsby Ltd Feb

Sangamo Weston Ltd Feb
Savage & Parsons Ltd Feb
Serck Radiators Ltd Feb
Service Electric Co Ltd A11
Shell Chemical Co Ltd Jan
Shell Mex & BP Ltd A60
Simmonds, L. E. Ltd A90
Simon-Carves Ltd Feb
Simplifix Couplings Ltd A77
Skinningrove Iron Co Ltd A57
Smith, J. & Sons (Clerkenwell) Ltd Feb
Spencer Chapman & Messel Ltd A73
Stabilag Co Ltd, The A88
Stainless Equipment Co Ltd Feb
Stainless Steel Profile Cutters Ltd A93
Standard & Pochin Bros Ltd, The Feb
Stanton Instruments Ltd Feb
Stephen, R. A. & Co Ltd A75
Stewarts & Lloyds Ltd Jan
Stonebridge Electrical Co Ltd, The A90
Suffolk Iron Foundry (1920) Ltd A88
Sunvic Controls Ltd Jan

Talbot Stead Tube Co Ltd A24, A25
Teddington Aircraft Controls Ltd Feb
Texas Instruments Ltd A64
Thermal Syndicate Ltd Feb
Thompson, John Ltd Cover 4
Timeg Ltd A86
Tubela Engineering Co Ltd A88
Tudor Accumulator Co Ltd Feb
Turners Film Productions A76
20th Century Electronics Ltd A9

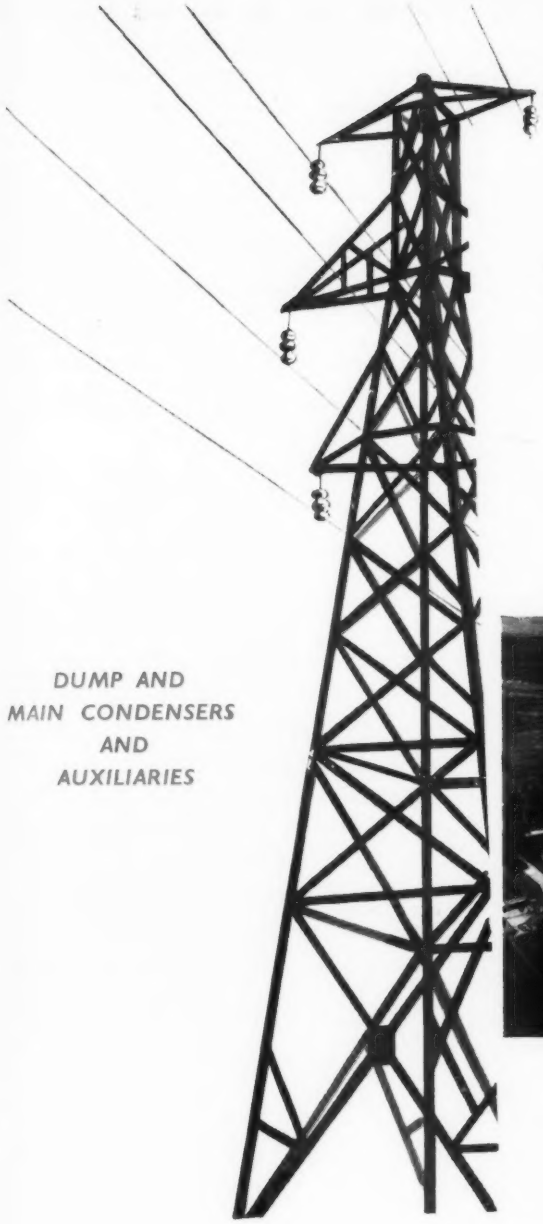
Unistrut Div of Sankey-Sheldon Ltd A39

Varatio-Strateline Gears Ltd Feb
Vernon, George Ltd A80
Vokes Genspring Ltd Feb
Vokes Ltd A42

Wakefield-Dick Industrial Oils Ltd A67
Wandleside Cable Works Ltd A40
Weatherfoil Heating Systems Ltd 137
Weir, G. & I. Ltd A20
Wellington Tube Works Ltd A33
Western Detail Manufacturers Ltd A35
Weston, Charles & Co Ltd A78
Westool Ltd Feb
Wharton Crane & Hoist Co Ltd, The A43
Whipp & Bourne Ltd Feb
Wiggin, Henry & Co Ltd Feb
Windshields of Worcester Ltd Feb
Willan, G. L. Ltd A5
Williams & James (Engineers) Ltd A89
Worthington-Simpson Ltd A51
Wright, Anderson & Co Ltd Feb

Yarrow & Co Ltd Feb
Yorkshire Engineering & Welding Co (Bradford) Ltd A80

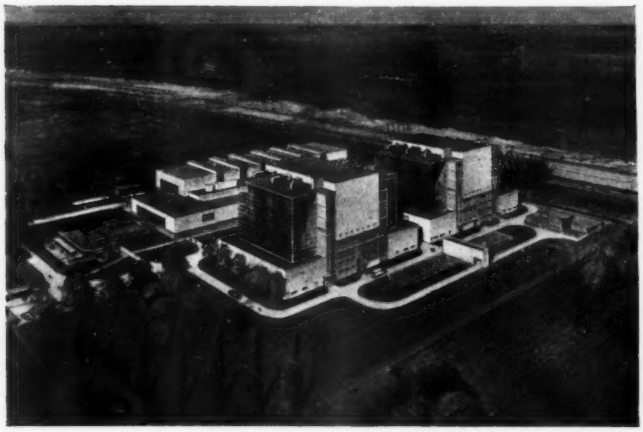
NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press, Ltd., S.E.5



DUMP AND
MAIN CONDENSERS
AND
AUXILIARIES

★'BATALBRA' TUBES
★'BATNAVAL' PLATES

for
POWER STATIONS
OF THE FUTURE



A major supplier for —

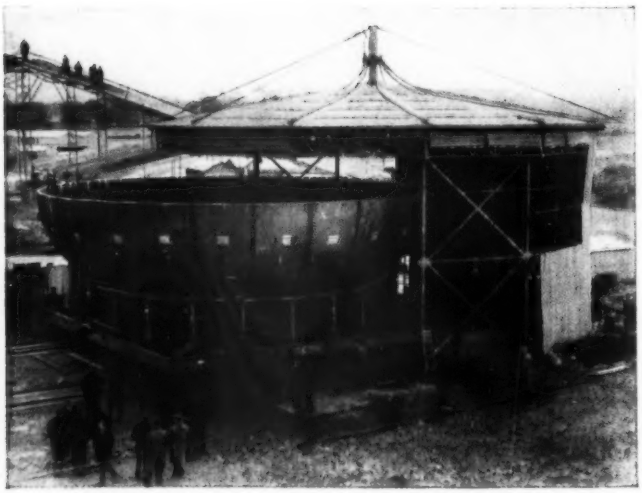
CALDER HALL B
CHAPEL CROSS
BRADWELL

with hundreds of tons of
'BATALBRA' TUBES
and a considerable tonnage of
'BATNAVAL' PLATES

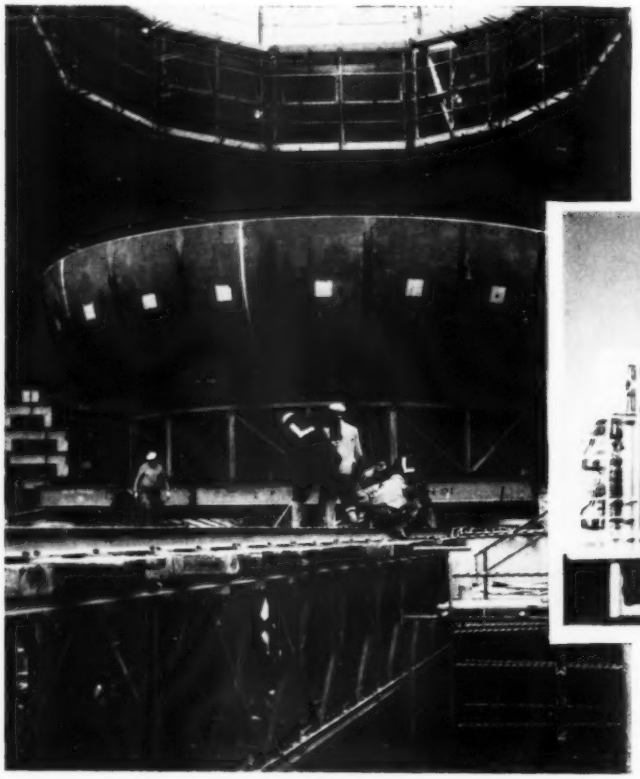
The BIRMINGHAM BATTERY and METAL CO LTD
SELLY OAK BIRMINGHAM 29

Over a Century of Independent Enterprise

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

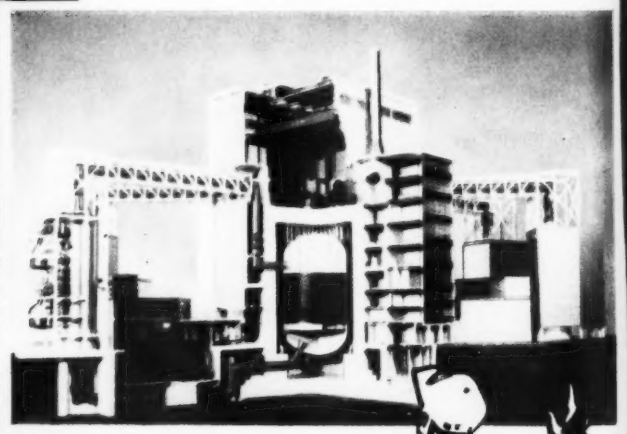


Above: While the foundations for the first of the station's two reactor vessels were being constructed, John Thompson teams of welders worked upon the lower bowl of the first reactor vessel on a temporary construction site, situated 180 yards from the final foundations. The three inch thick steel plates were pressed, prepared for welding and trial assembled at John Thompson's Wolverhampton works before transportation to site, where they were welded to class I pressure vessel standards.
And below: On Sunday, 20th October, the 180 tons bowl was moved on its railed bogie from the shelter of the temporary construction site to its permanent foundations.



Buttercups at Berkeley...

John Thompson's construction men—familiar in their yellow helmets on power station and industrial sites throughout Britain—are now at work on the Central Electricity Authority's first commericial nuclear power station being built by the A.E.I.-John Thompson Nuclear Energy Company at Berkeley, Gloucestershire. Crisply, the construction programme proceeds to a minutely planned schedule. The 1,000-ton reactor vessel for Number 1 reactor is growing simultaneously with the reactor building. The " Buttercups " are speedily getting on with this job in which they are building the reactor vessels, the thermal shielding, the sixteen large heat exchange towers, gas ducting and nuclear fuel loading machines.



JOHN THOMPSON GROUP

JOHN THOMPSON LIMITED

JOHN THOMPSON WATER TUBE BOILERS LTD · WOLVERHAMPTON

WTA/15

ar

's
g

re.
eds to

ng
e

or
ge
ear

WTA/15